

When to Install VSD Chillers

Spencer Fuller and Fred Berry, *Johnson Controls*
Keynote Speakers



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PDH Certificates will be e-mailed to Attendees within two days.

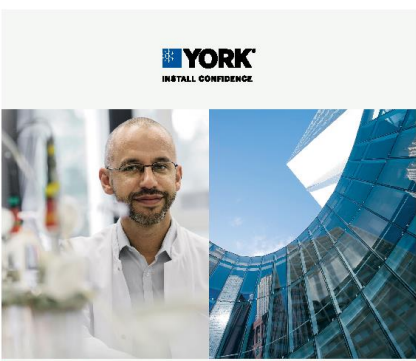


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CHILLER & COOLING BEST PRACTICES


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Handouts




YORK
INSTALL CONFIDENCE

YORK® YMC® Chiller:
The new standard in chiller technology



Project Profile
Waldo County General Hospital
Belfast, Maine




New cooling system brings reliable comfort, redundancy and energy efficiency


Waldo County General Hospital is a not-for-profit community hospital committed to providing excellent care for patients and their families in a friendly, caring atmosphere in line with its mission to be the best. Focused on patient comfort, energy savings and improved operational efficiency, the hospital contracted Johnson Controls to replace its cooling system. As a result, the hospital will save an estimated \$477K annually in electricity costs, provide reliable cooling and achieve a four-year return on its investment.

Challenged with an inefficient chiller that required a high level of costly maintenance, the hospital needed a cost-effective solution for replacing the chiller, in an effort to reduce energy and operating costs. In addition, the hospital wanted to create a level of redundancy in its cooling system to ensure the consistent comfort of its patients and staff.

Johnson Controls has been servicing the hospital's Meray™ building management system since the early 1990's and the existing chiller since its installation. After conducting a study of the hospital's cooling needs, the Johnson Controls service team proposed a solution that would not only meet the hospital's requirements, but also reduce future costs and eliminate the environmentally unfriendly refrigerant used in the existing chiller. In addition, Johnson Controls leveraged available funding to offset the cost of the project.



Project Profile
Financial Institution
Fort Worth, Texas




Regardless of the original manufacturer, YORK® OptiSpeed™ Variable-Speed Drives improve chiller operation

More than 100 years ago, this nationally known financial institution was founded and has been igniting opportunities and pursuing innovation ever since. With locations across the nation, Fort Worth, Texas, is home to a company-owned office building and data center, housing more than 2,500 employees, where the bank is continuing this pursuit of innovation in the way the building is operated.

To keep its occupants comfortable throughout the 460,000 square foot, two-story building, chilled water was being produced by constant-speed Carrier® Centrifugal Chillers. While the system provided adequate comfort, facility managers knew it had limited potential for energy savings. So when the customer began to focus on reducing energy consumption and cost, it reached out to Johnson Controls to develop a more efficient means of producing chilled water. The solution was built around the latest in variable-speed drive technology.

Johnson Controls has been manufacturing variable-speed drives for centrifugal chillers since 1979. Today's YORK® OptiSpeed™ Variable-Speed Drives (VSDs) are designed to cut chiller energy use and CO₂ emissions by as much as 30% a year. YORK VSDs are universally applicable, too; they can be installed on any chiller, regardless of brand. With that flexibility, the Johnson Controls team installed YORK VSDs on the customer's Carrier chillers as part of an overall strategy to deliver energy and operational savings.



The Magazine for ENERGY EFFICIENCY and WATER CONSERVATION in Industrial Cooling Systems

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22 Adiabatic Cooling Keeps Pace with Growing Data Center Heat Density

5 online & mobile tools to help you



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COOLING SYSTEM OPTIMIZATION

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24 A Review of Solid-Form Scale and Corrosion Inhibitors

COOLING TOWERS & CHILLERS

18 Evaluating Air Compressor Cooling Systems

5 online & mobile tools to help you



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All materials presented are educational. Each system is unique and must be evaluated on its own merits.

When to Install VSD Chillers

Introduction by *Rod Smith*, Publisher
Chiller & Cooling Best Practices Magazine



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About the Speakers



Spencer Fuller

- North America Portfolio Manager for Johnson Controls
- Chiller Product Manager of YMC²



Fred Berry

- Chiller Product Manager of Large Tonnage Chillers and Electronic Products for Johnson Controls



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YORK®

OPTIMIZING ENERGY USE WITH VSD CHILLERS



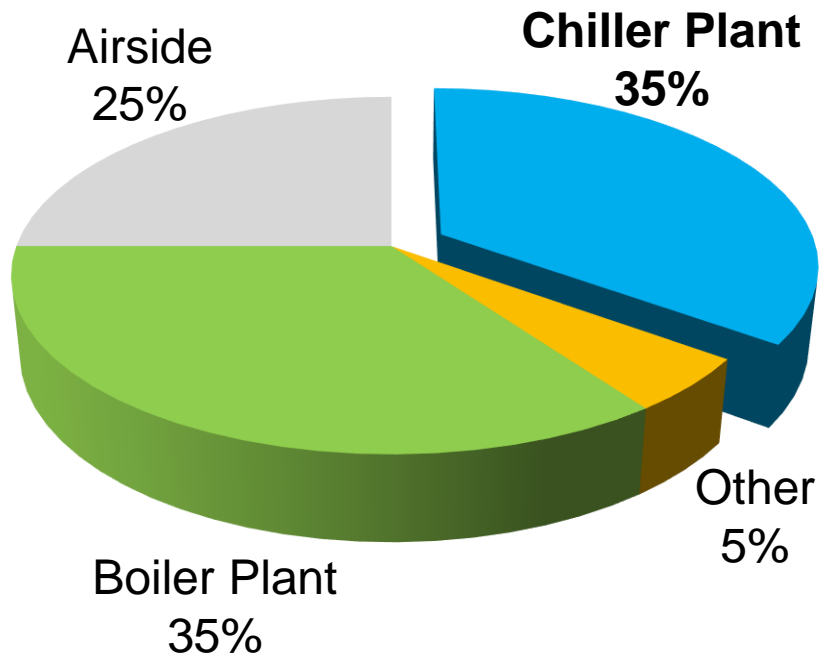
Today's Agenda

- **Real World Efficiency**
- **Lift vs. Load**
- **Benefits of VSD technology**
- **More chillers operating is more efficient**
- **Constant load with VSD saves money**
- **Air-Cooled chillers with VSD technology**
- **Conclusion**

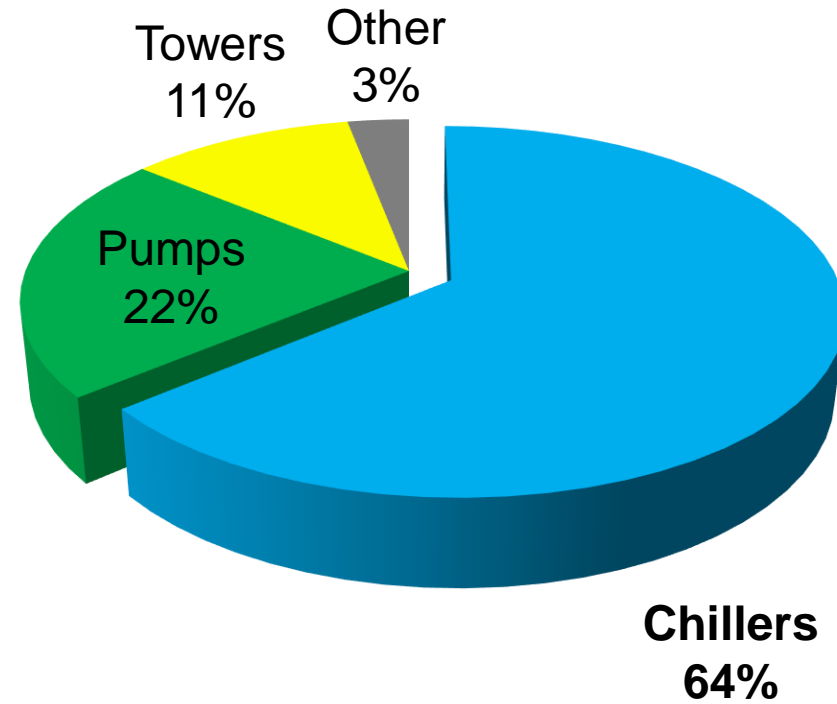
Addressing Sustainability

Chiller Energy Consumption is Critical to Driving Sustainability

Total HVAC Energy Use for Commercial Building Utilizing Water Cooled Systems



Total Chiller Plant Energy Use



Understanding the Impact of Energy Efficiency

Centrifugal chillers are the largest single energy consumer in the building.

Energy Costs vs. First Costs



First Costs
Typical 1000 TR
\$300,000 Equipment only

Annual energy cost is ~ 41% of first cost

A keen focus
on real world
energy
performance
delivers real
value

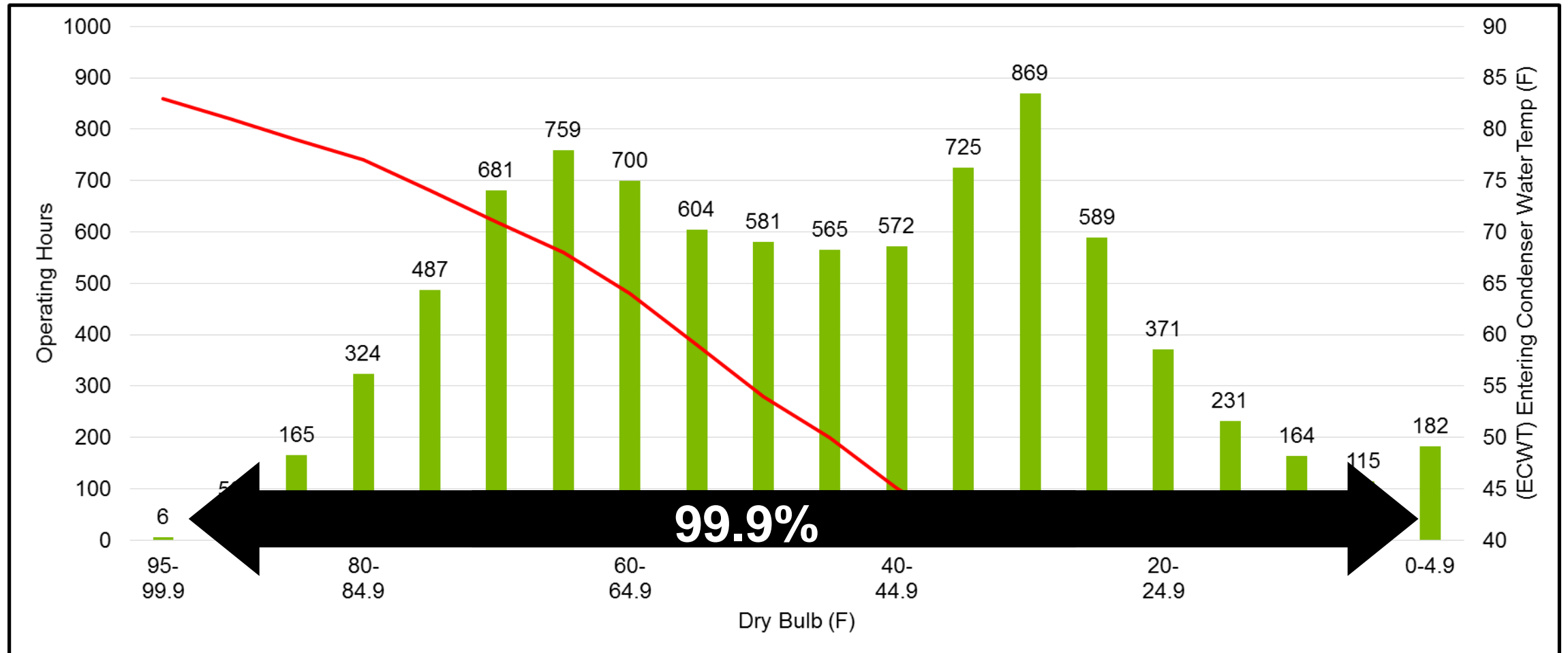
Energy Over Chiller Lifetime

Lifetime energy cost is ~ \$6M

**How often do we operate
our buildings at design
conditions?**

Real World Energy Performance

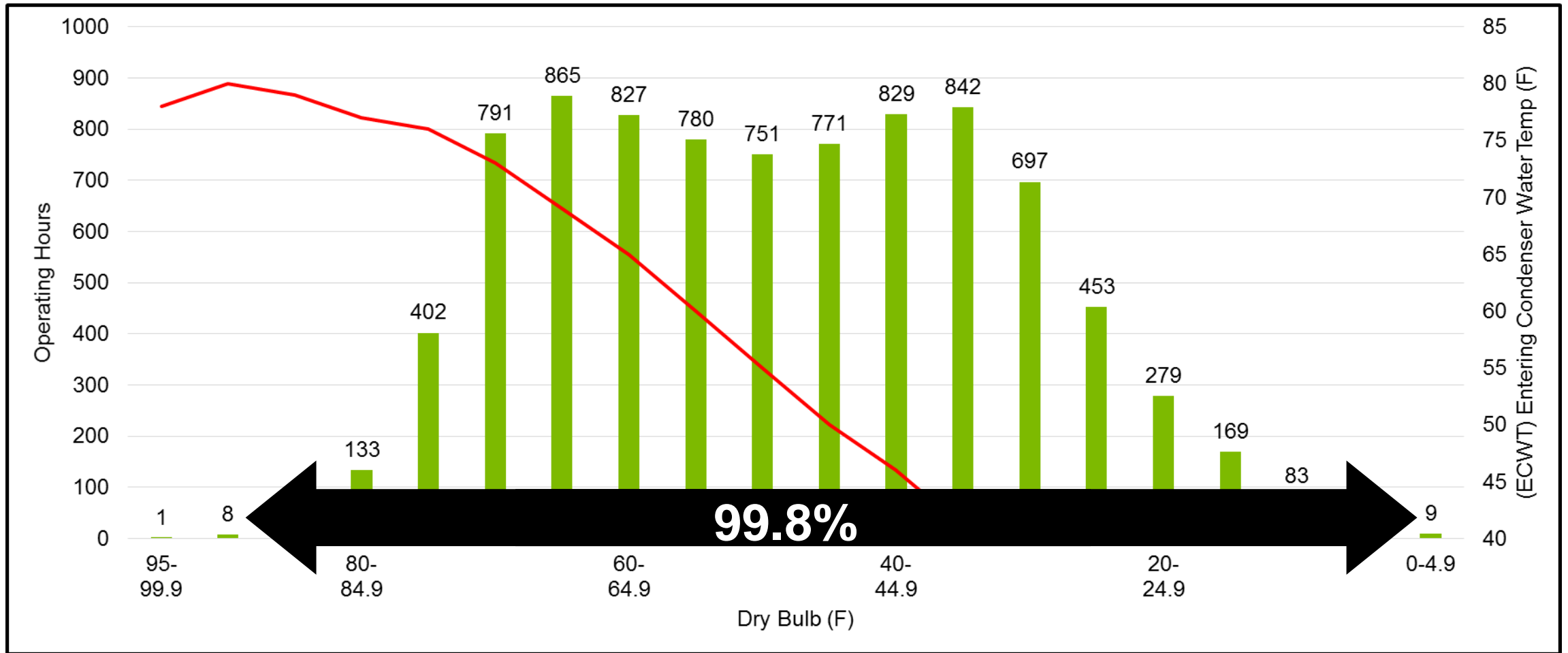
The Operating Envelope – Chicago, IL Weather



Chillers run at “full-load design” conditions Less than 1% of the time!

Real World Energy Performance

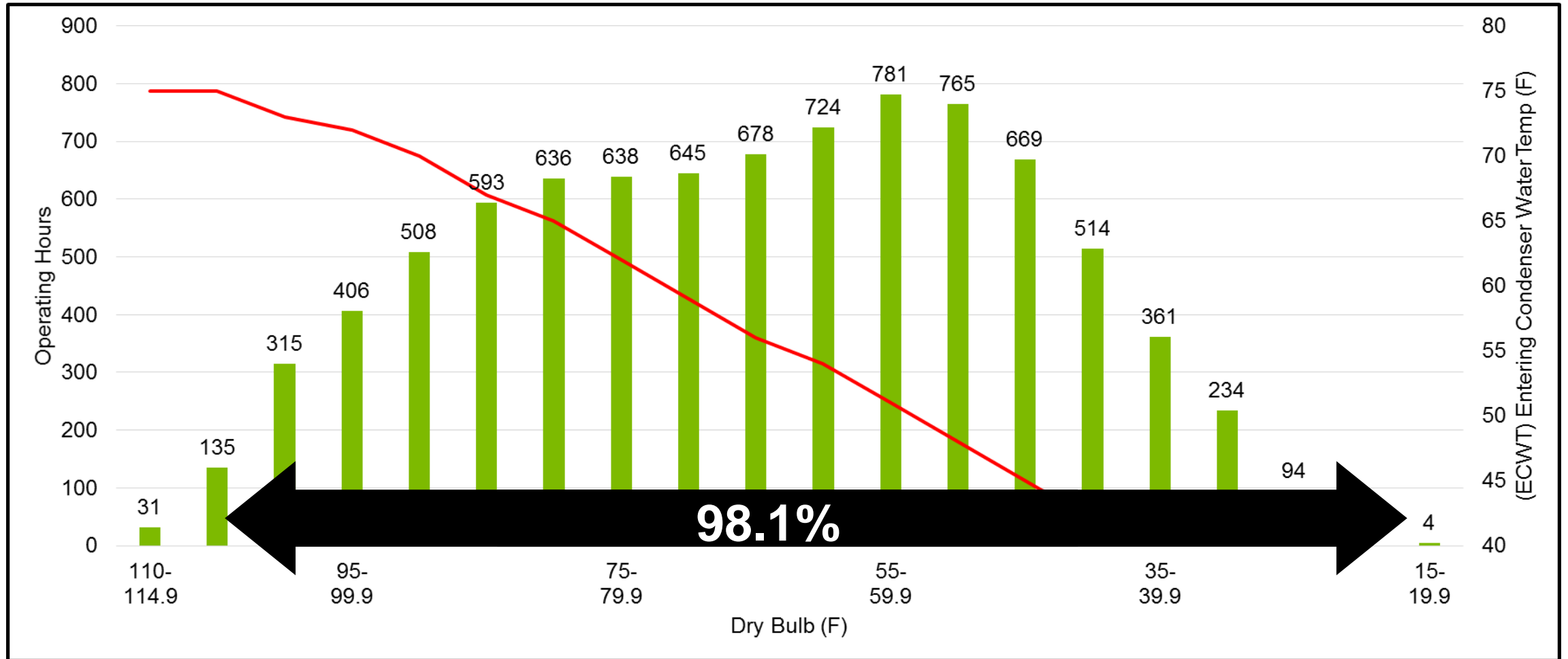
The Operating Envelope – New York City, NY Weather



Chillers run at “full-load design” conditions Less than 1% of the time!

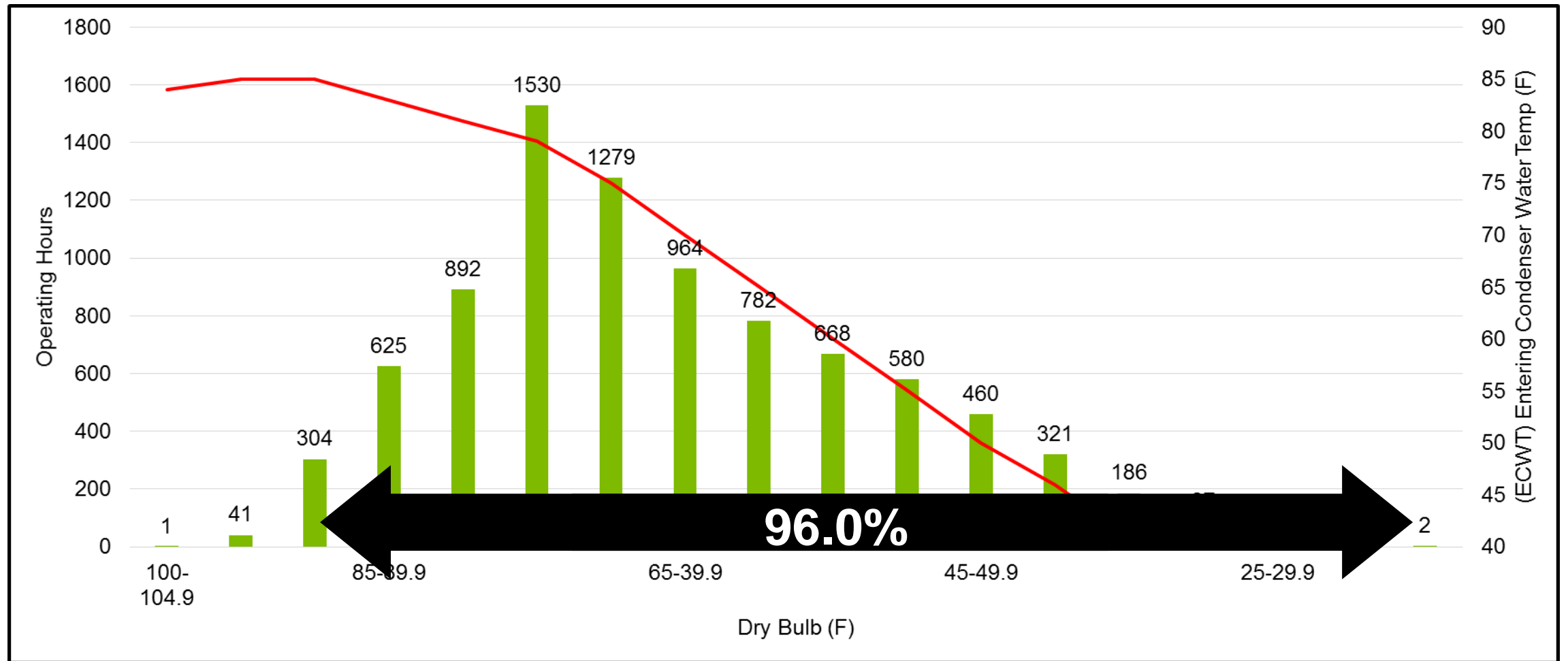
Real World Energy Performance

The Operating Envelope – Las Vegas, NV Weather



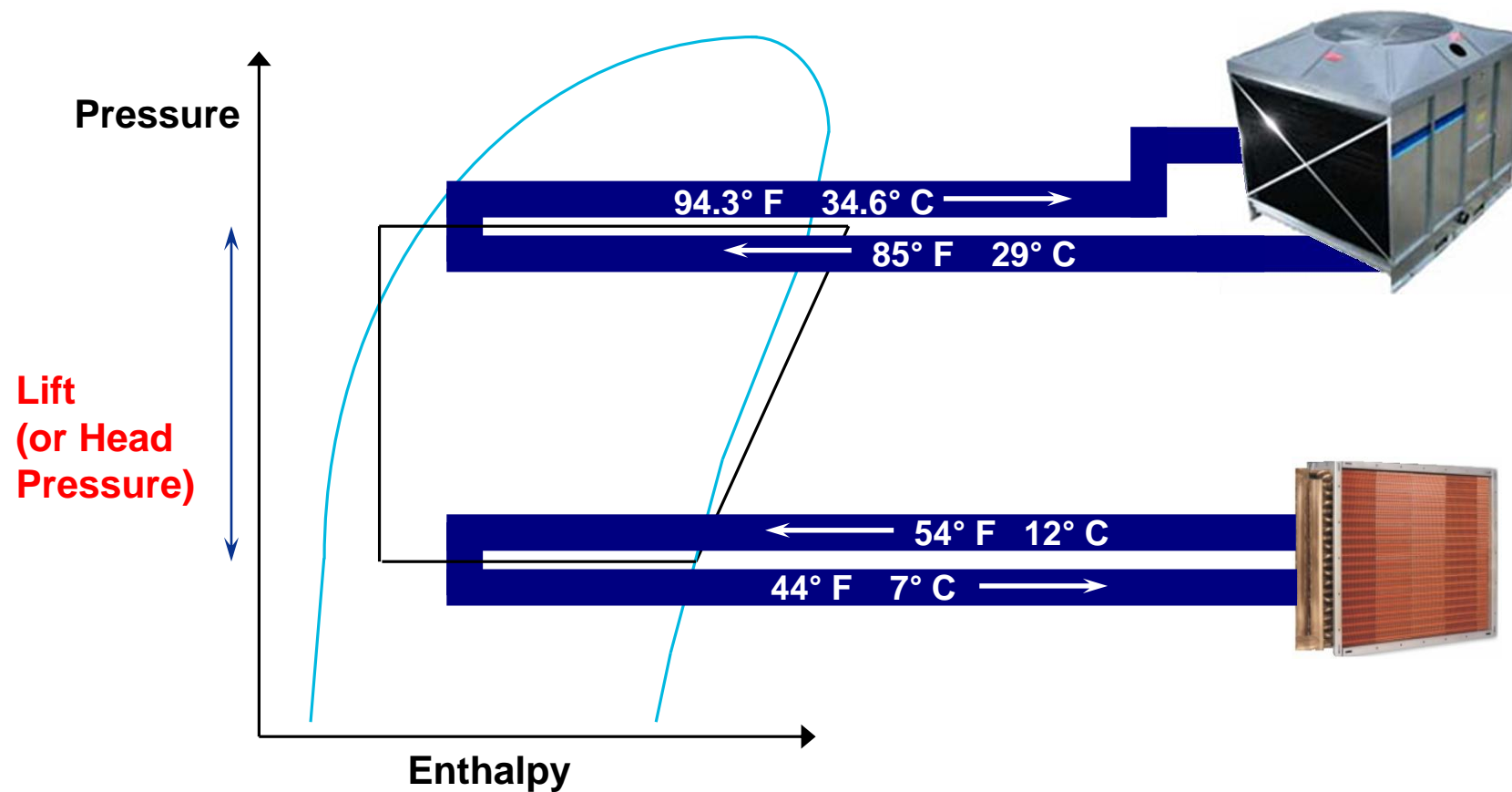
Real World Energy Performance

The Operating Envelope – Houston, TX Weather



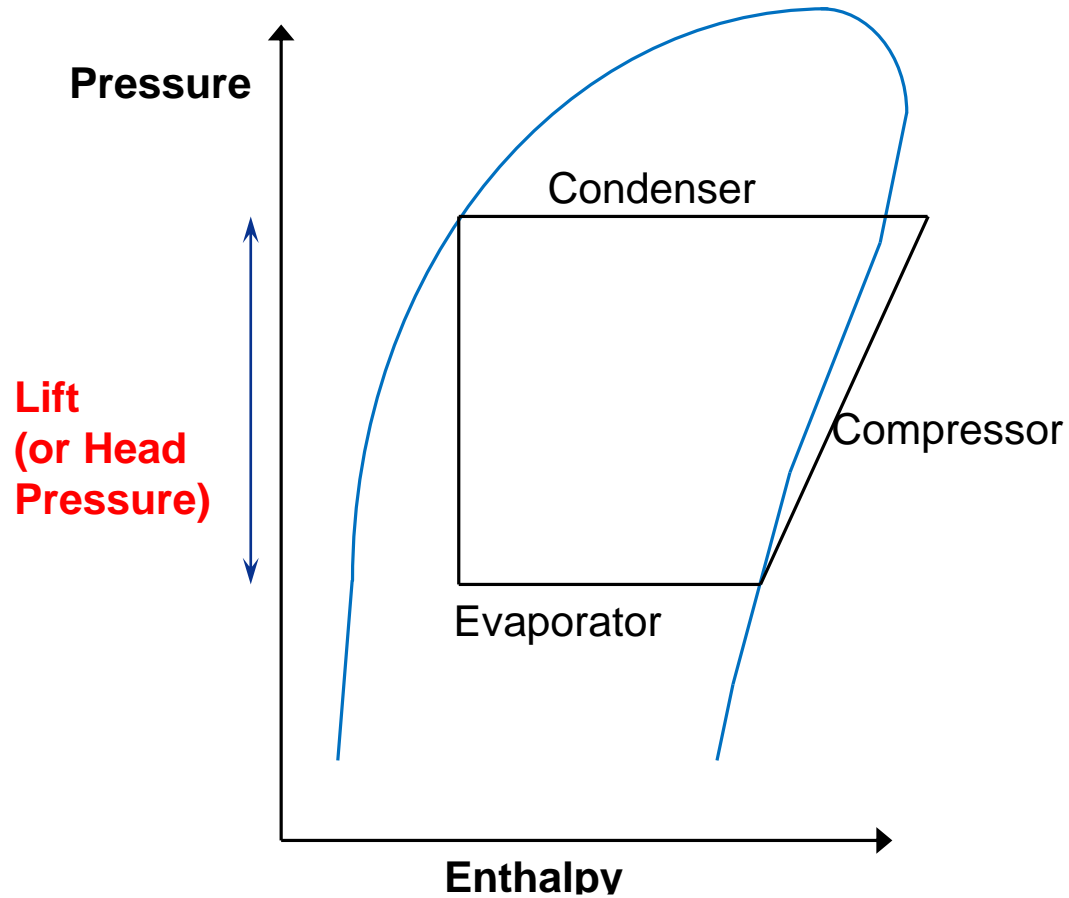
Centrifugal Chillers in Today's Complex Buildings

How They Work



Real World Energy Performance

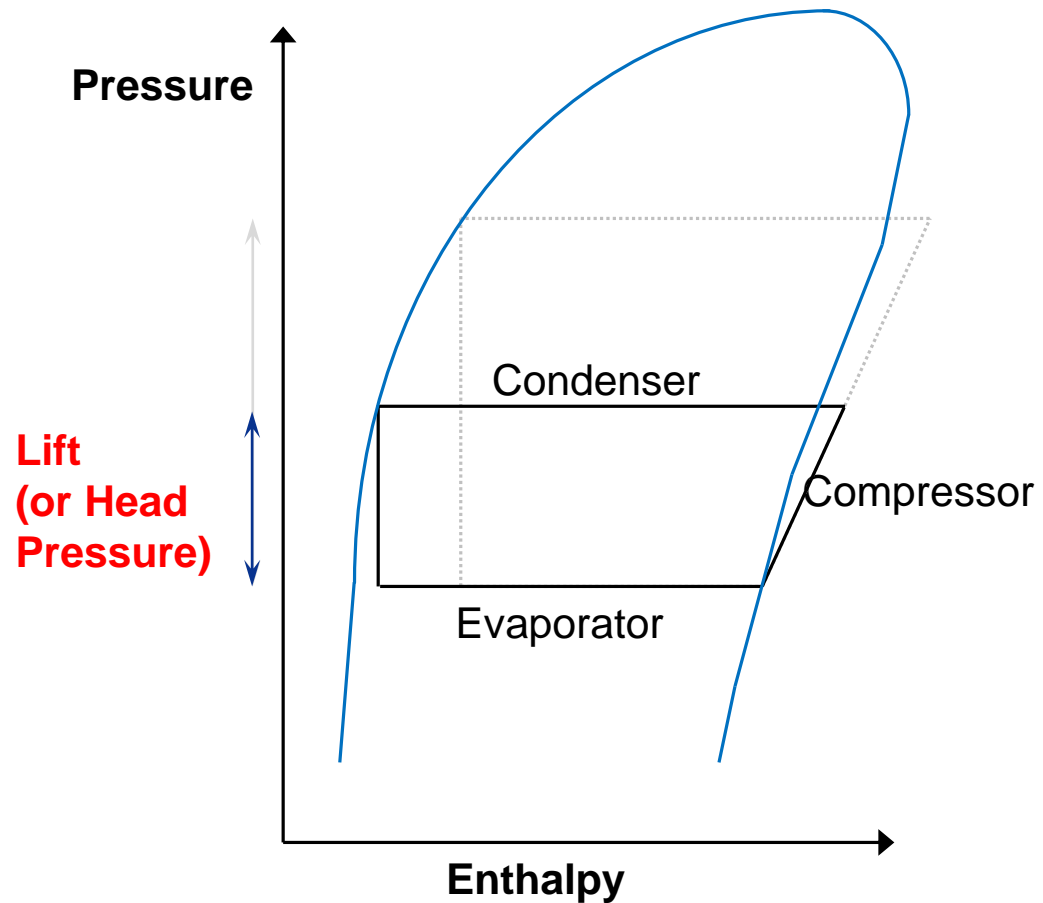
Capitalizing on Part Load Conditions



**Lowering Condenser
Water Temperature**

Real World Energy Performance

Capitalizing on Part Load Conditions



**Lowering Condenser
Water Temperature**



Lowers the Lift



**Reduces Compressor
Work**



**Reduces Energy
Consumption**

Rule of Thumb

Component power

- Cooling Tower = 5hp/100ton
- Pumps (2x) = 10hp/100ton
- Chiller = 70-80hp/100ton

Chiller efficiency improvements

- 1 degree colder ECWT is up to 2% efficiency improvement
- 1 degree warmer LCHWT is up to 3% efficiency improvement

Rule of Thumb

Component power

- Cooling Tower = 5hp/100ton
- Pumps (2x) = 10hp/100ton
- Chiller = 70-80hp/100ton

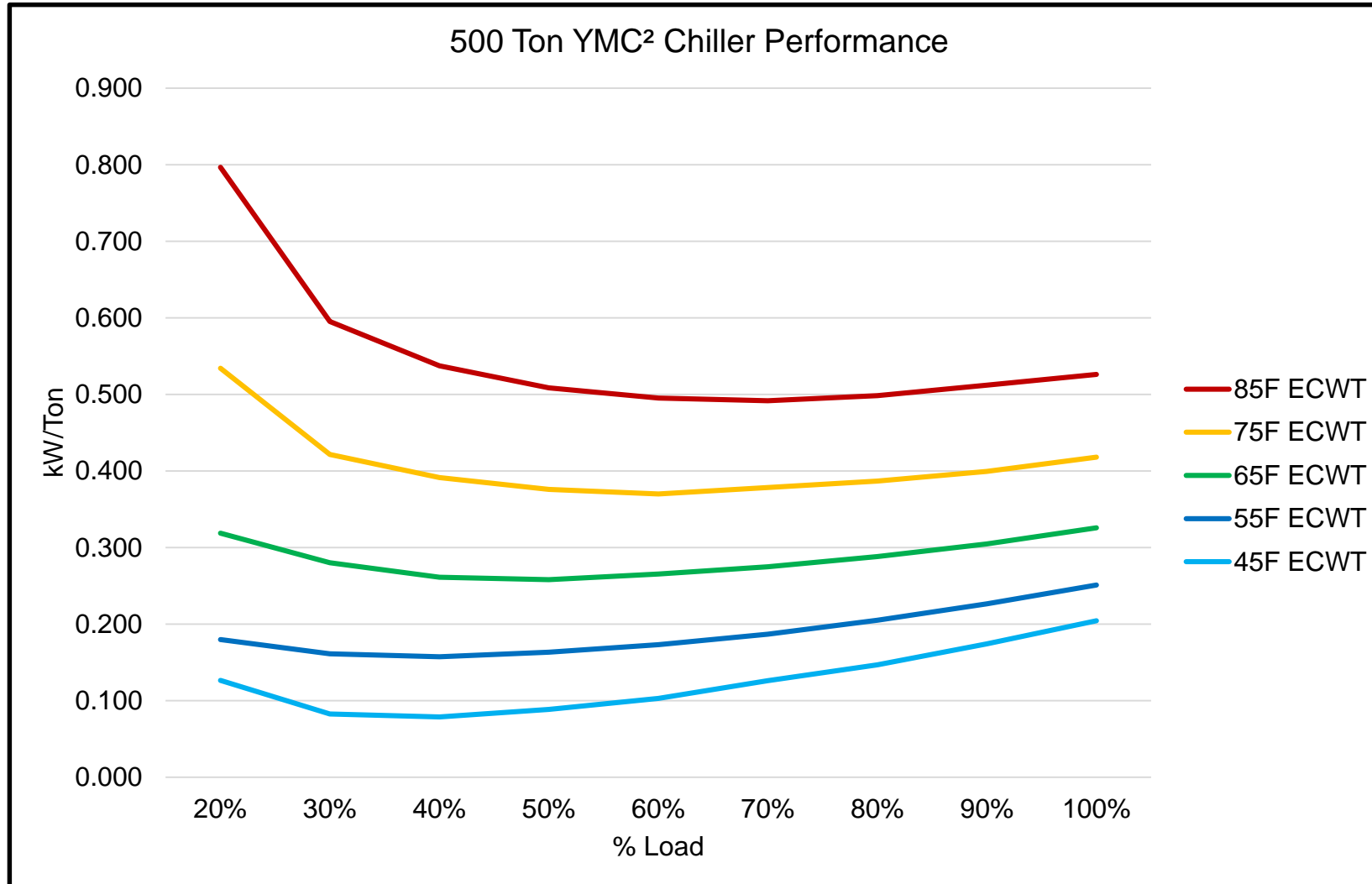
Ex: 500 TR Chiller

- Cooling Tower = 25hp = 18.75kW
- Evap Pump = 25hp = 18.75kW
- Cond Pump = 25hp = 18.75kW
- Chiller = 390hp = 292.5kW

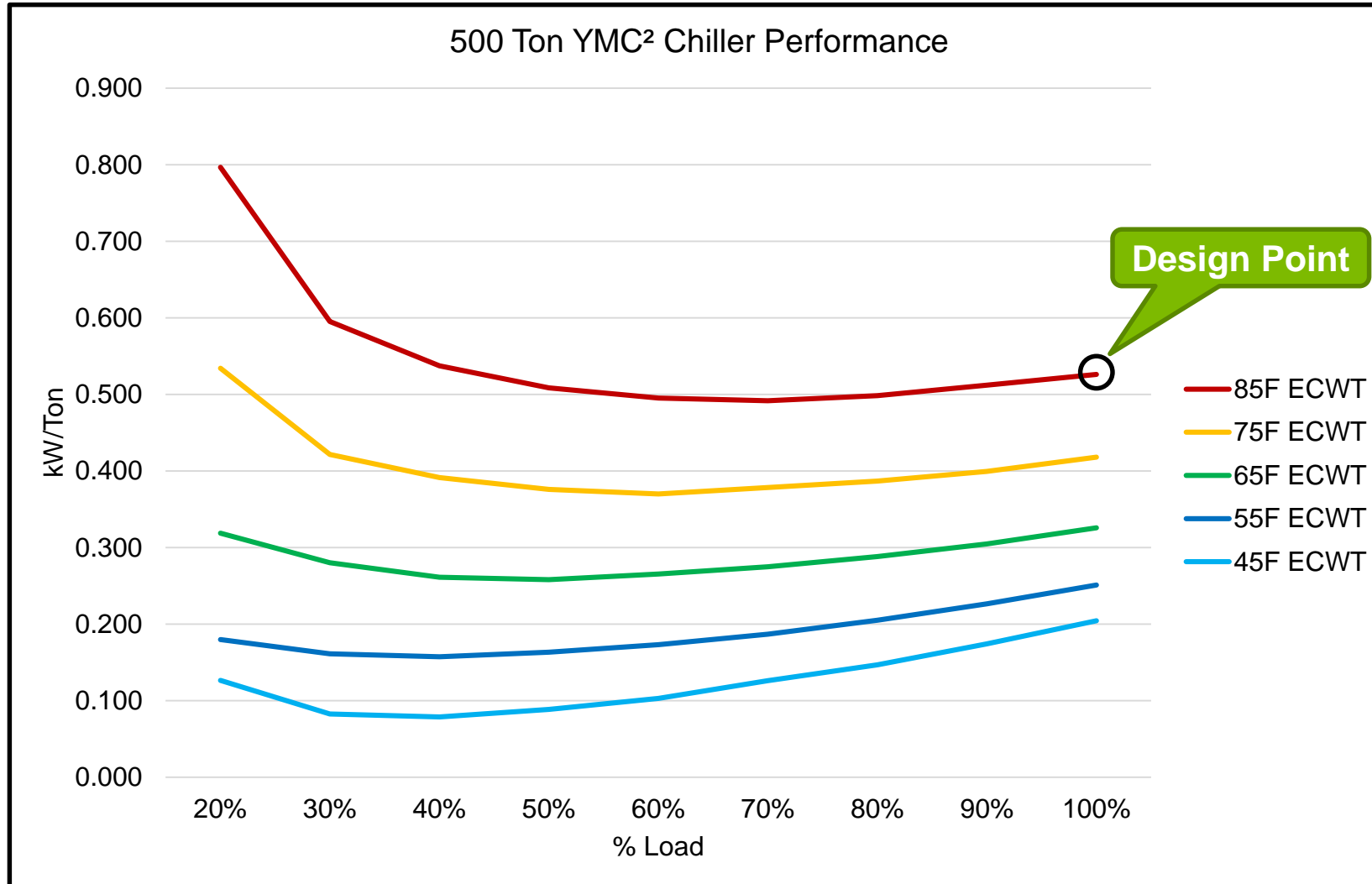
Chiller efficiency improvements

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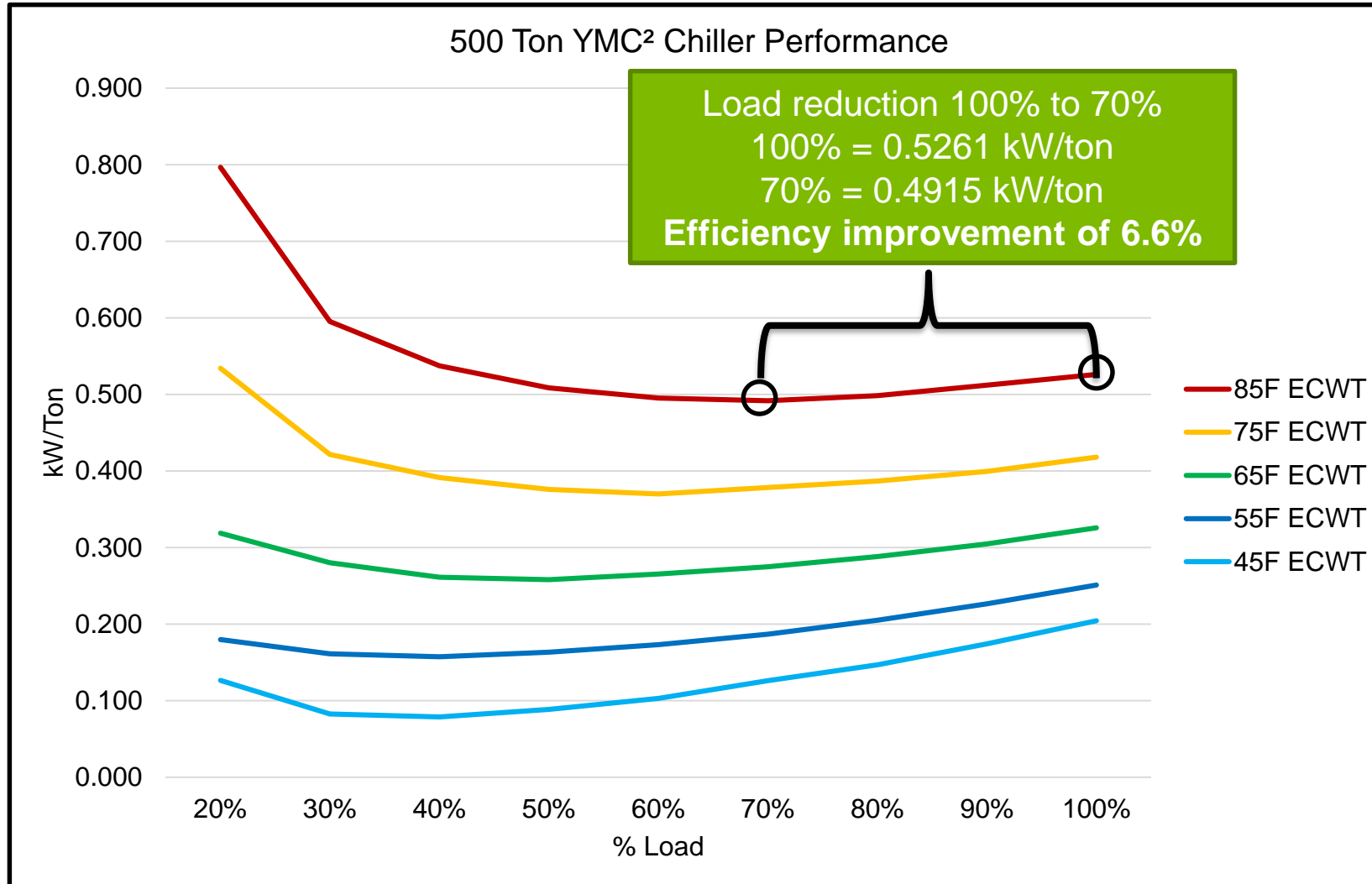
Energy Usage Based on Lift and Load



Energy Usage Based on Lift and Load

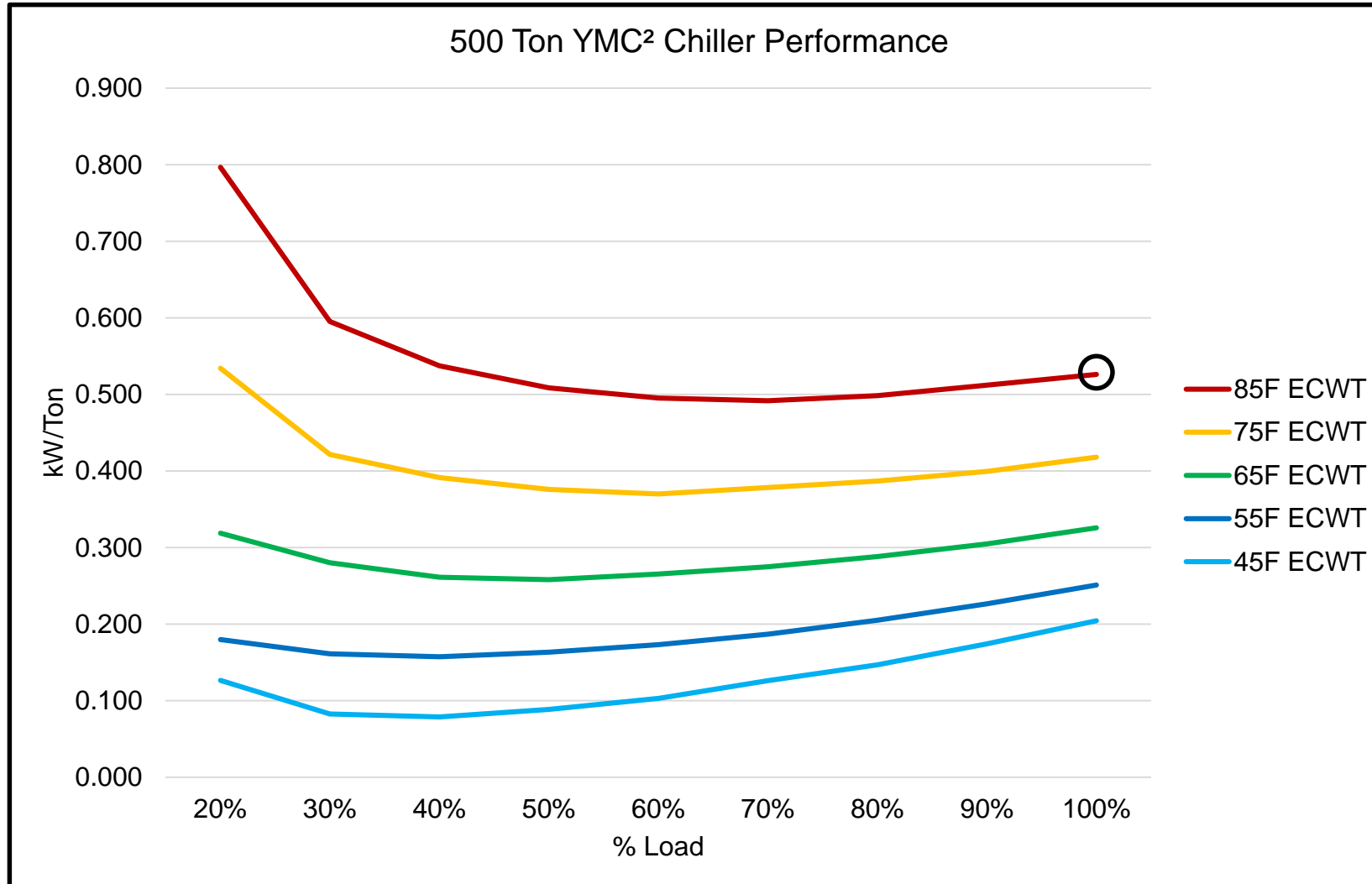


Energy Usage Based on Lift and Load



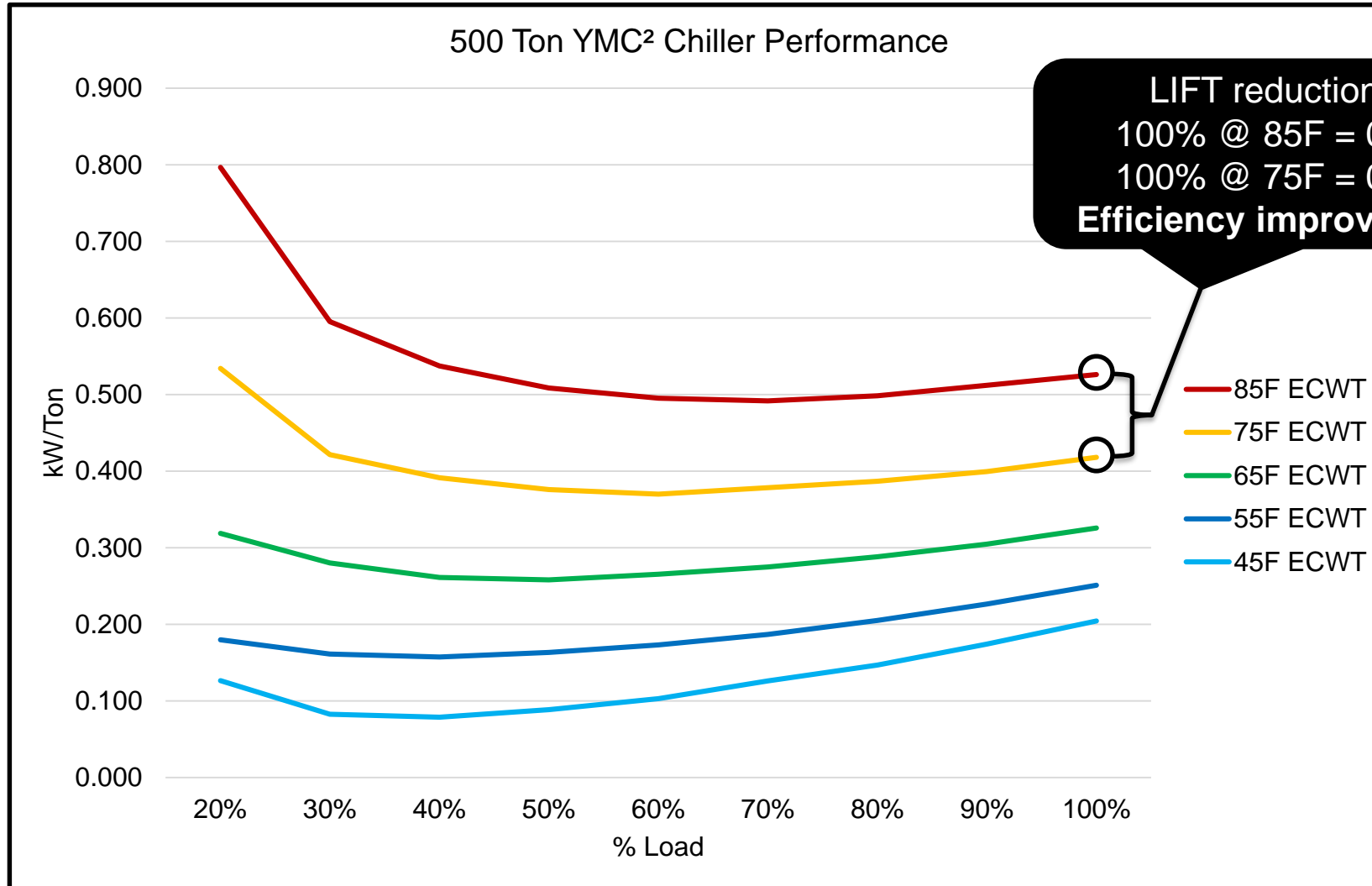
Energy Usage Based on Lift and Load

Load reduction 100% to 70%
100% = 0.5261 kW/ton
70% = 0.4915 kW/ton
Efficiency improvement of 6.6%



Energy Usage Based on Lift and Load

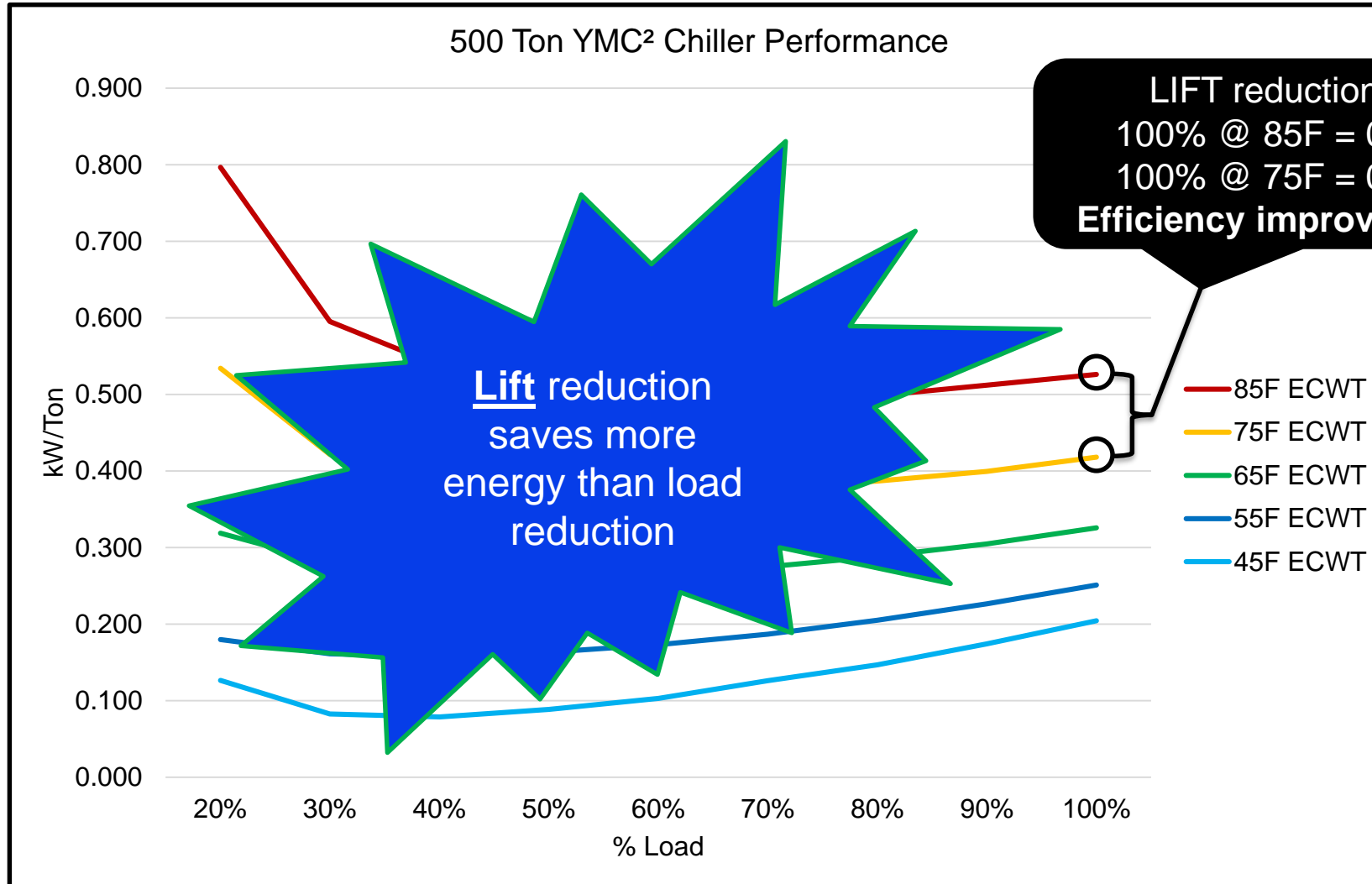
Load reduction 100% to 70%
100% = 0.5261 kW/ton
70% = 0.4915 kW/ton
Efficiency improvement of 6.6%



LIFT reduction 85F to 75F
100% @ 85F = 0.5261 kW/ton
100% @ 75F = 0.4179 kW/ton
Efficiency improvement of 20.5%

Energy Usage Based on Lift and Load

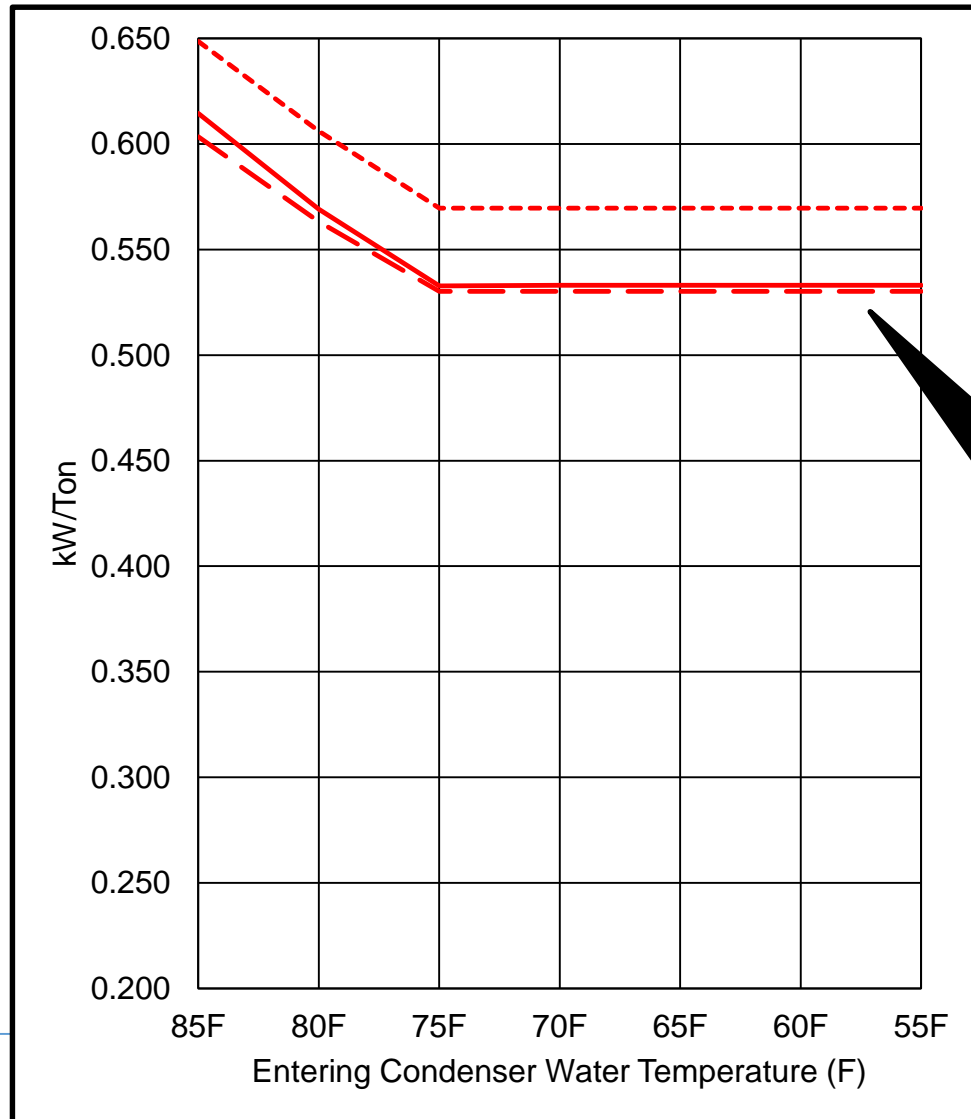
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Efficiency improvement of 6.6%



LIFT reduction 85F to 75F
100% @ 85F = 0.5261 kW/ton
100% @ 75F = 0.4179 kW/ton
Efficiency improvement of 20.5%

Real World Energy Performance

Capitalizing on Part Load Conditions -ECWT vs kW/ton



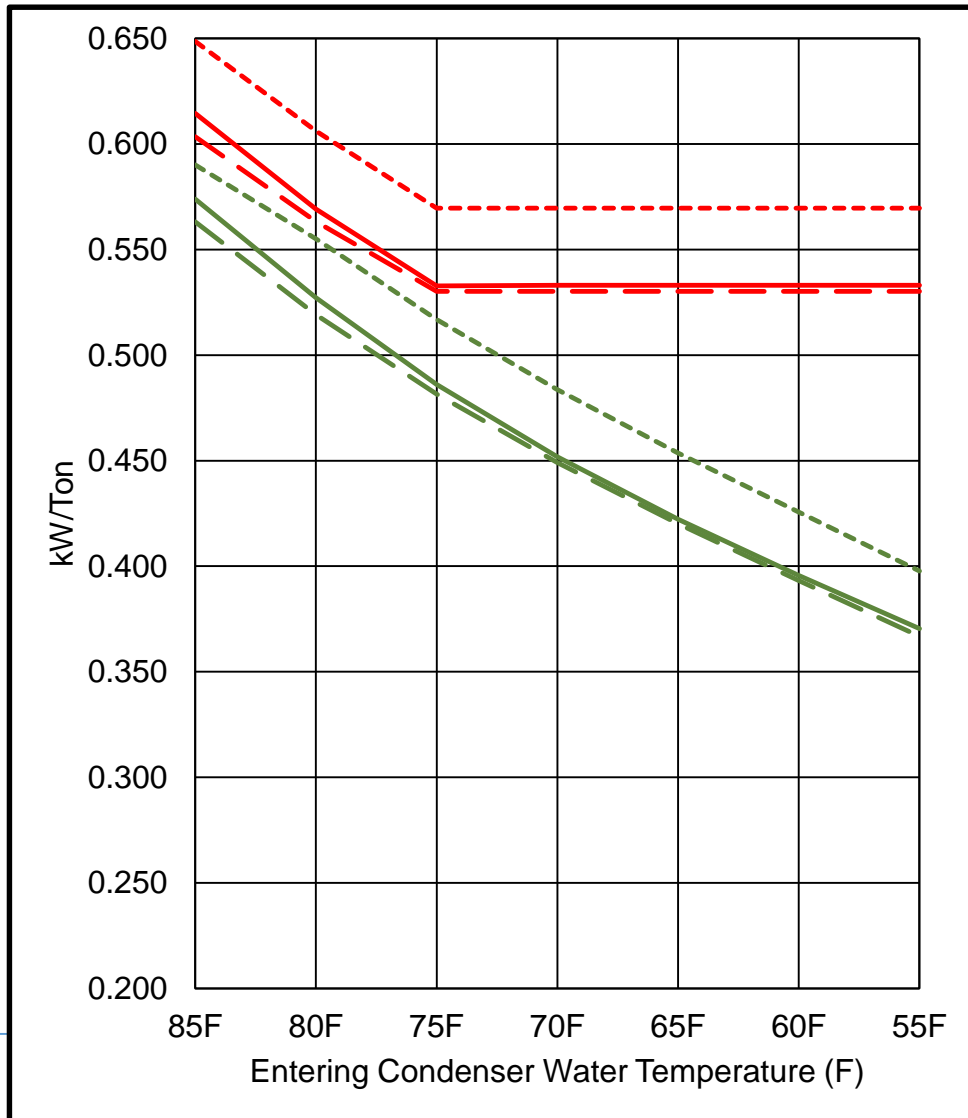
**Traditional – Constant Speed
w/ Fixed Orifice**

50% Load - - - - -
100% Load - - - - -
80% Load - - - - -

“Flat Line” caused by
the use of Head
Pressure Control
(HPC) systems

Real World Energy Performance

Capitalizing on Part Load Conditions -ECWT vs kW/ton



**Traditional – Constant Speed
w/ Fixed Orifice**

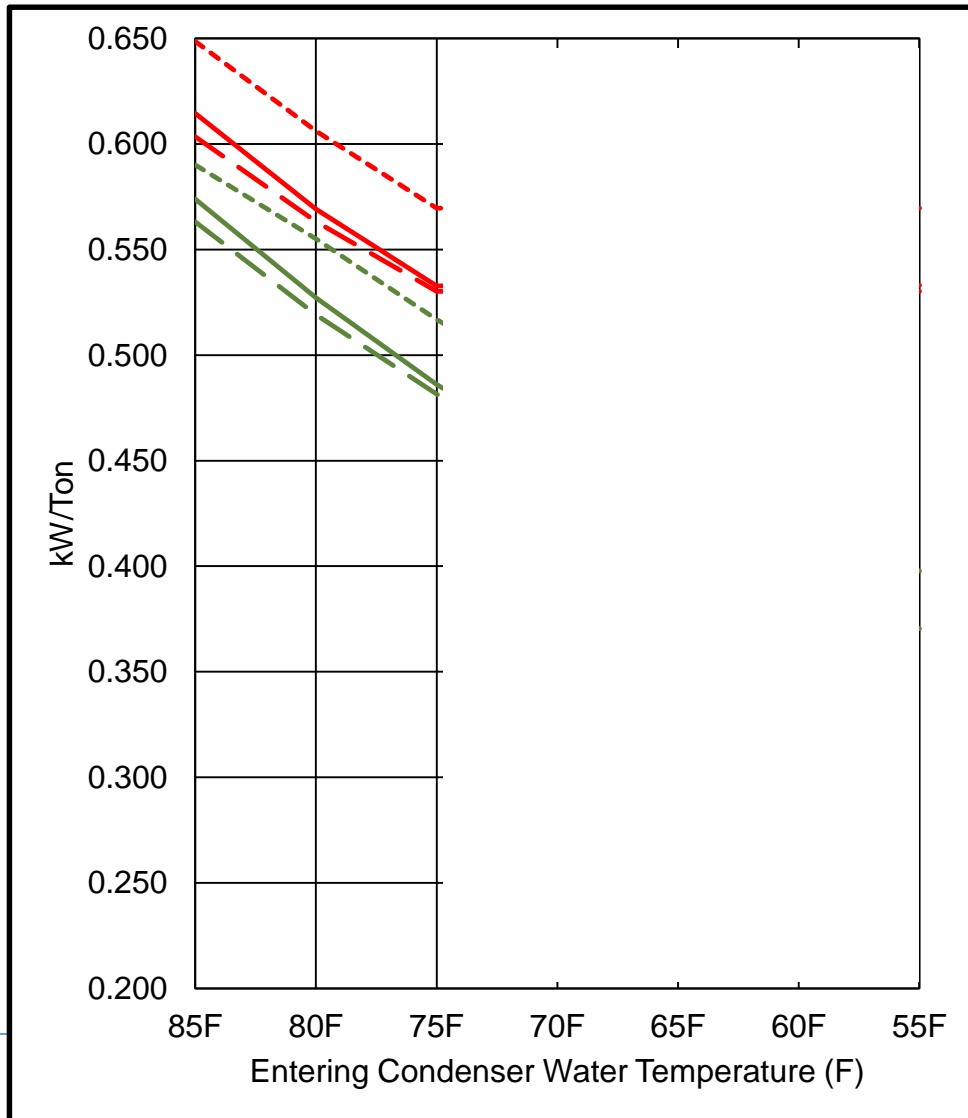
50% Load - - - - -
100% Load - - - - -
80% Load - . - . - .

**New - Constant Speed
w/ Variable Orifice**

50% Load - - - - -
100% Load - - - - -
80% Load - . - . - .

Real World Energy Performance

Capitalizing on Part Load Conditions -ECWT vs kW/ton



**Traditional – Constant Speed
w/ Fixed Orifice**

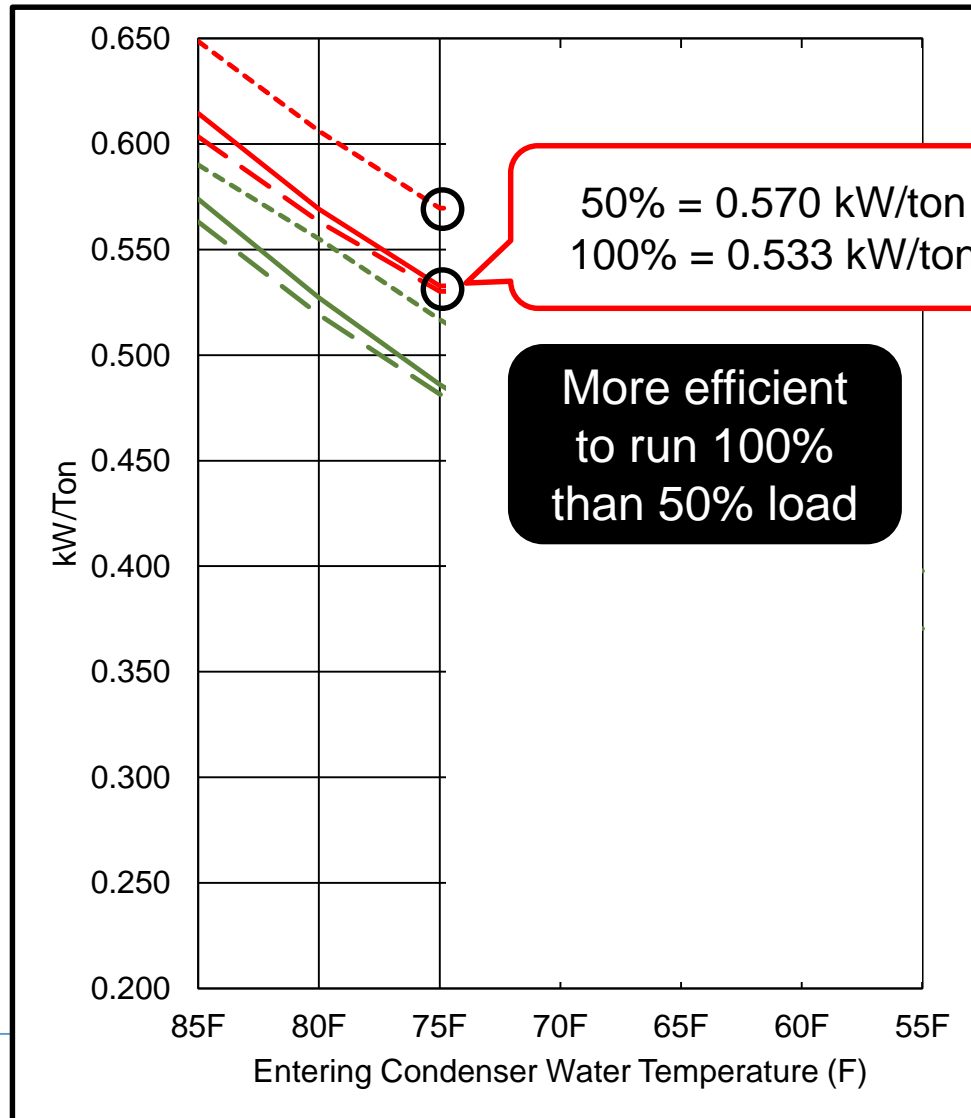
50% Load -----
100% Load _____
80% Load - - - - -

**New - Constant Speed
w/ Variable Orifice**

50% Load -----
100% Load _____
80% Load - - - - -

Real World Energy Performance

Capitalizing on Part Load Conditions -ECWT vs kW/ton



**Traditional – Constant Speed
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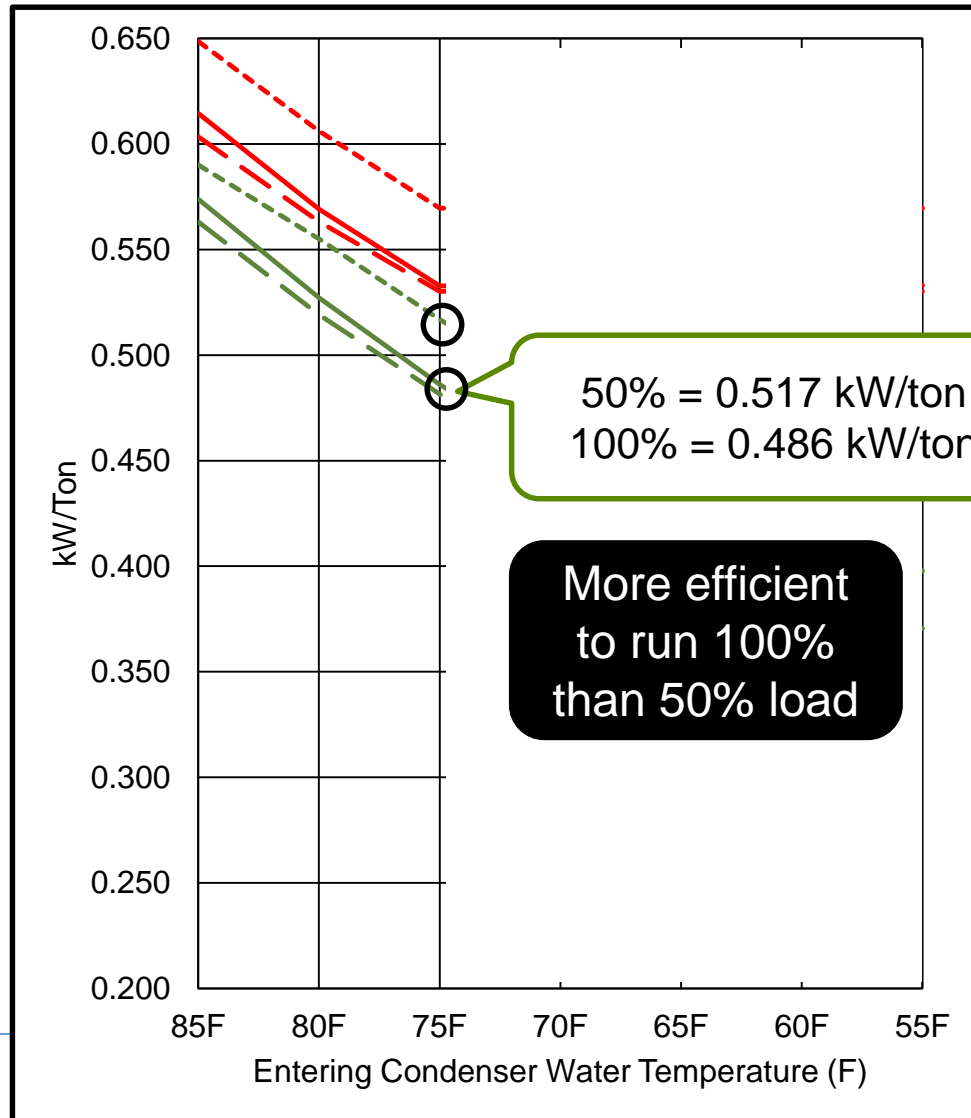
50% Load -----
100% Load _____
80% Load — — — —

**New - Constant Speed
w/ Variable Orifice**

50% Load -----
100% Load _____
80% Load — — — —

Real World Energy Performance

Capitalizing on Part Load Conditions -ECWT vs kW/ton



**Traditional – Constant Speed
w/ Fixed Orifice**

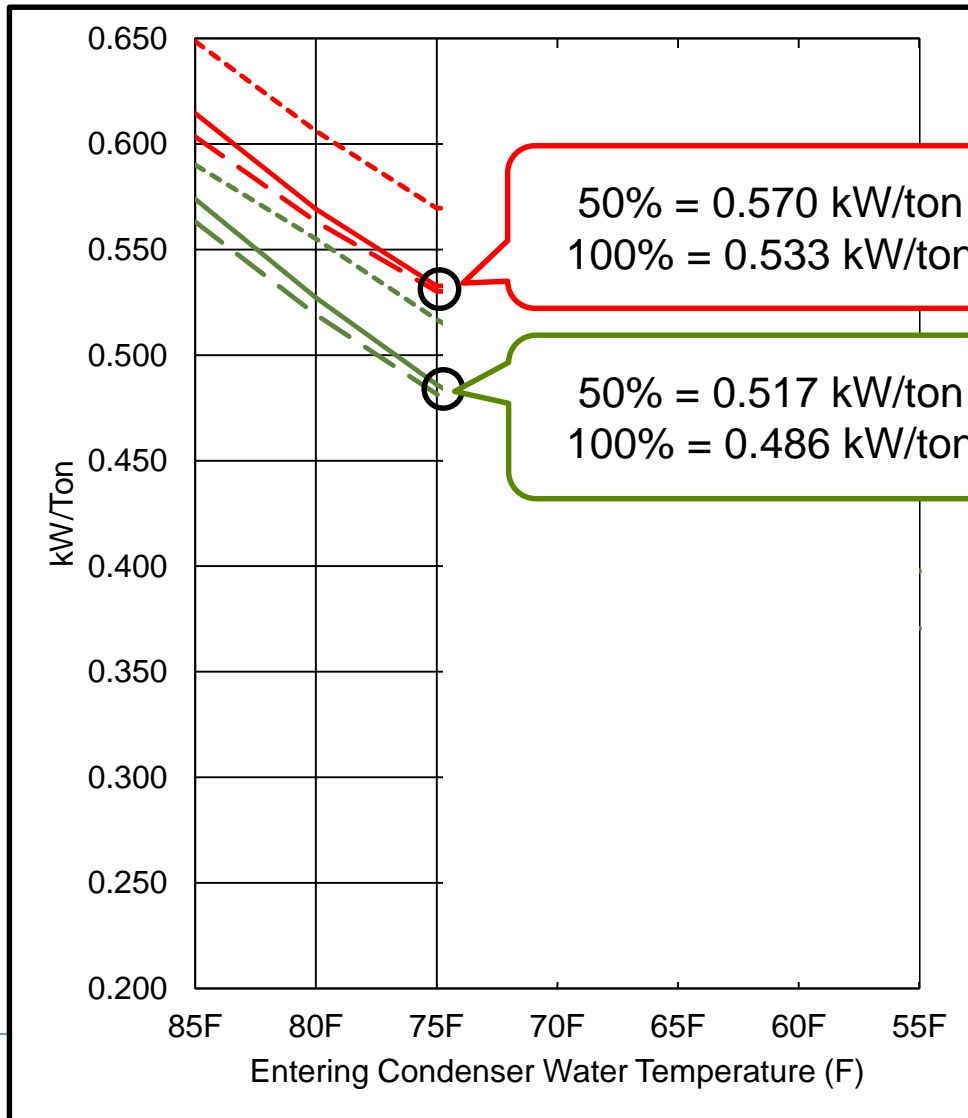
50% Load -----
100% Load _____
80% Load - - - -

**New - Constant Speed
w/ Variable Orifice**

50% Load -----
100% Load _____
80% Load - - - -

Real World Energy Performance

Capitalizing on Part Load Conditions -ECWT vs kW/ton

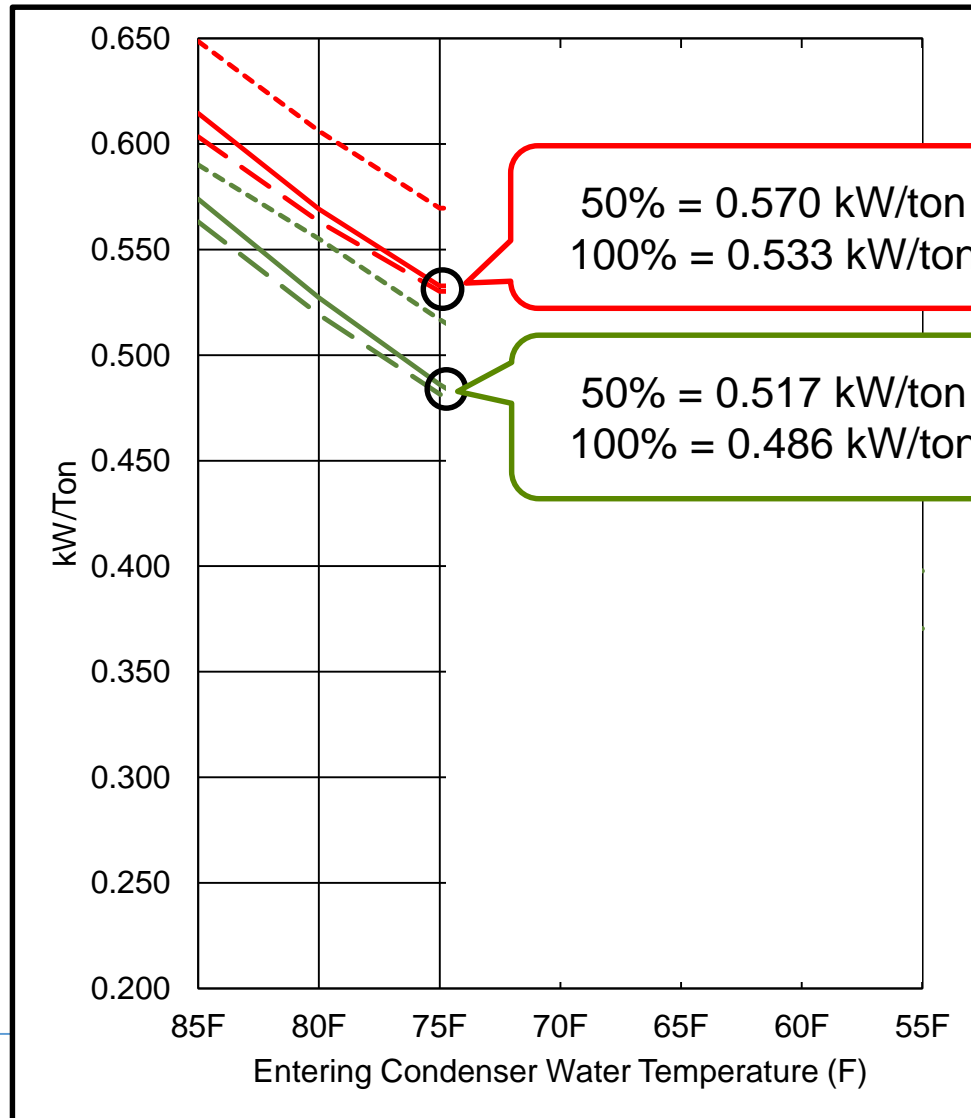


**Traditional – Constant Speed
w/ Fixed Orifice**

**New - Constant Speed
w/ Variable Orifice**

Real World Energy Performance

Capitalizing on Part Load Conditions -ECWT vs kW/ton



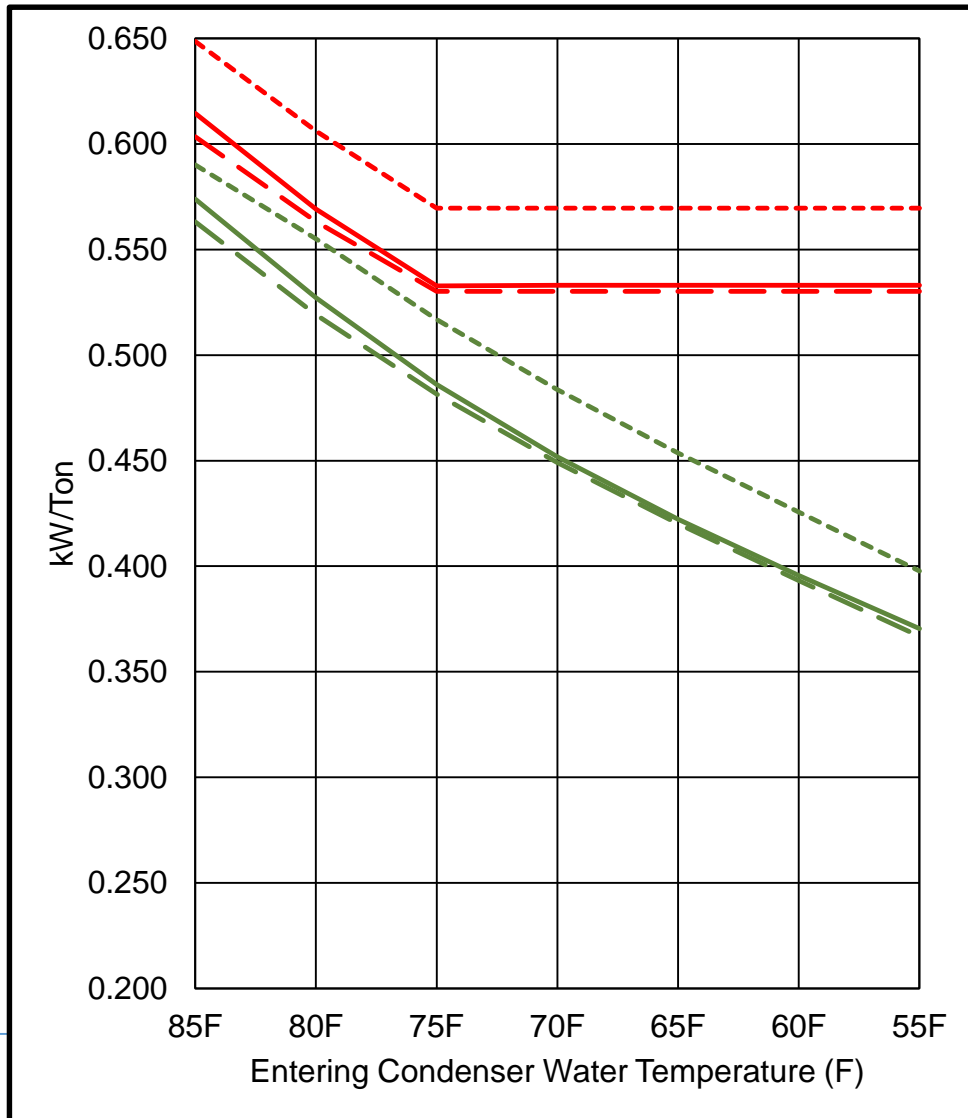
**Traditional – Constant Speed
w/ Fixed Orifice**

**New - Constant Speed
w/ Variable Orifice**

Assume 500ton chiller
50% load - difference of 13.25kW
100% load - difference of 23.5kW

Real World Energy Performance

Capitalizing on Part Load Conditions -ECWT vs kW/ton



**Traditional – Constant Speed
w/ Fixed Orifice**

50% Load - - - - -
100% Load - - - - -
80% Load - . - . - .

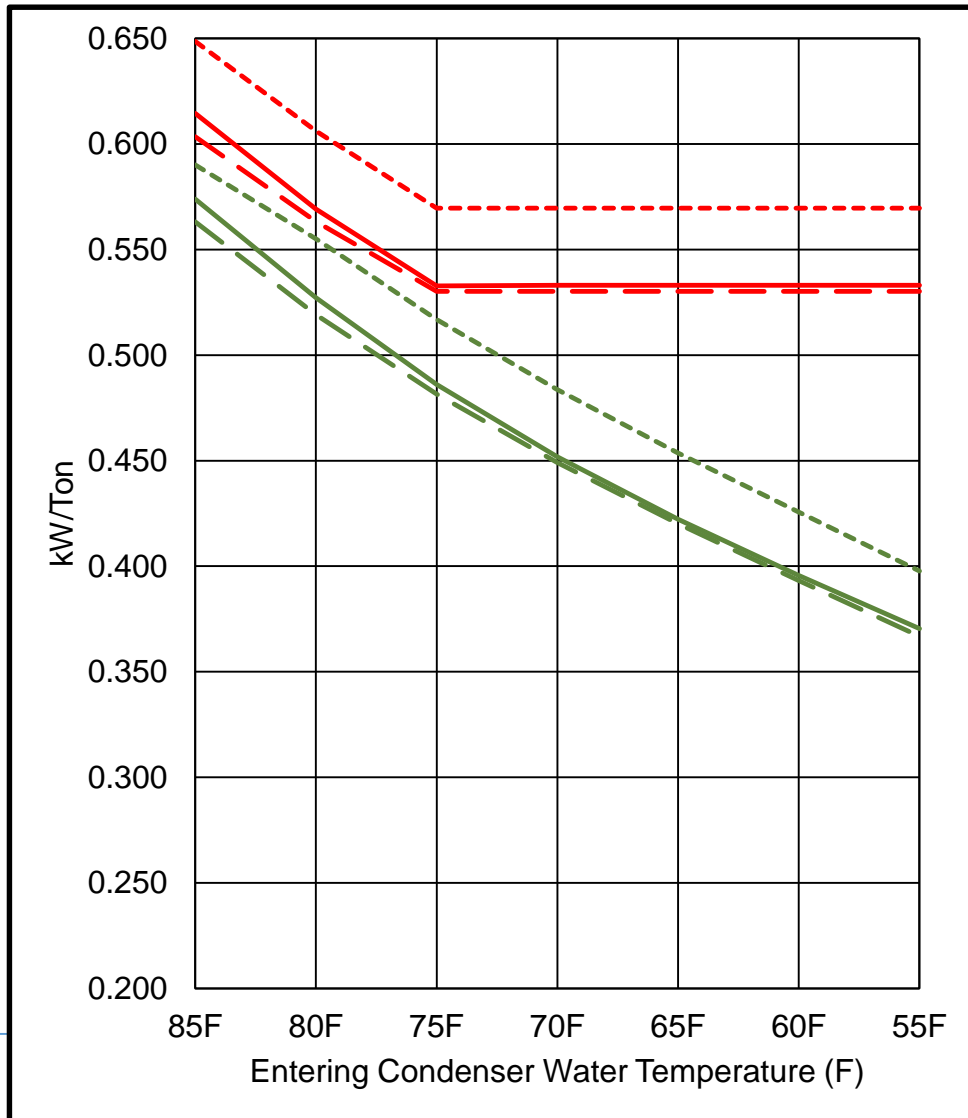
**New - Constant Speed
w/ Variable Orifice**

50% Load - - - - -
100% Load - - - - -
80% Load - . - . - .

More efficient to run 100%
than 50% load

Real World Energy Performance

Capitalizing on Part Load Conditions -ECWT vs kW/ton



**Traditional – Constant Speed
w/ Fixed Orifice**

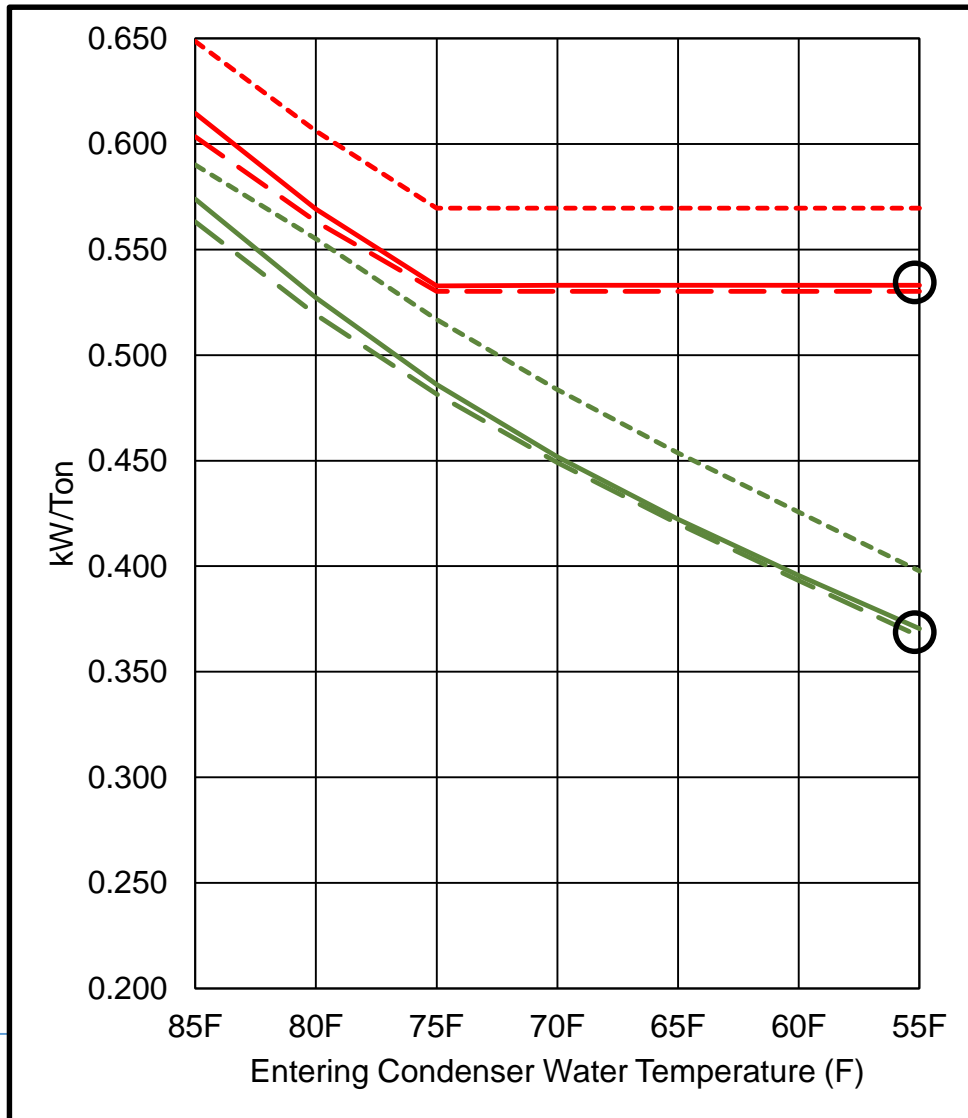
50% Load - - - - -
100% Load - - - - -
80% Load - - - - -

**New - Constant Speed
w/ Variable Orifice**

50% Load - - - - -
100% Load - - - - -
80% Load - - - - -

Real World Energy Performance

Capitalizing on Part Load Conditions -ECWT vs kW/ton



**Traditional – Constant Speed
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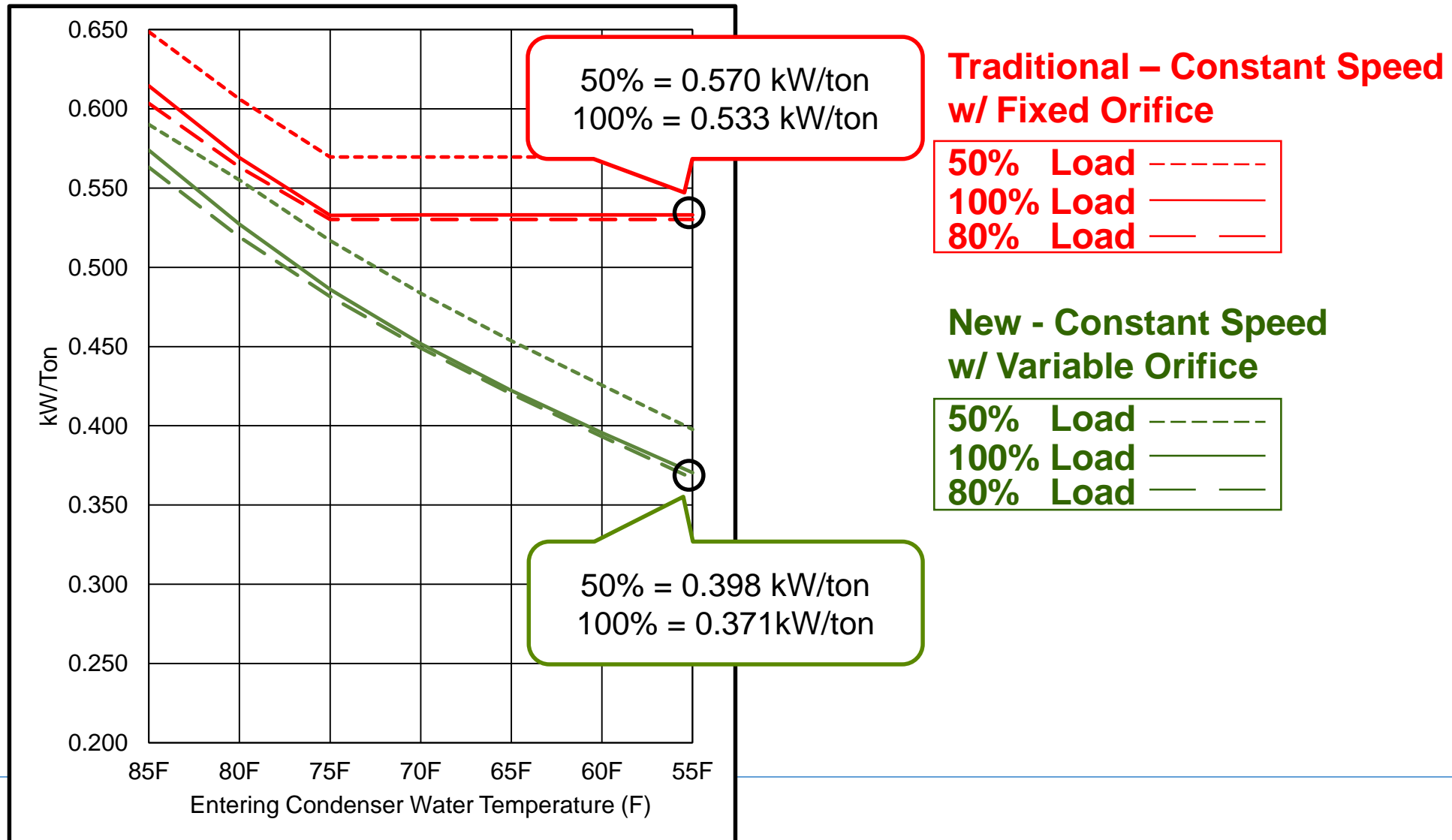
50% Load - - - - -
100% Load - - - - -
80% Load - . - . - .

**New - Constant Speed
w/ Variable Orifice**

50% Load - - - - -
100% Load - - - - -
80% Load - . - . - .

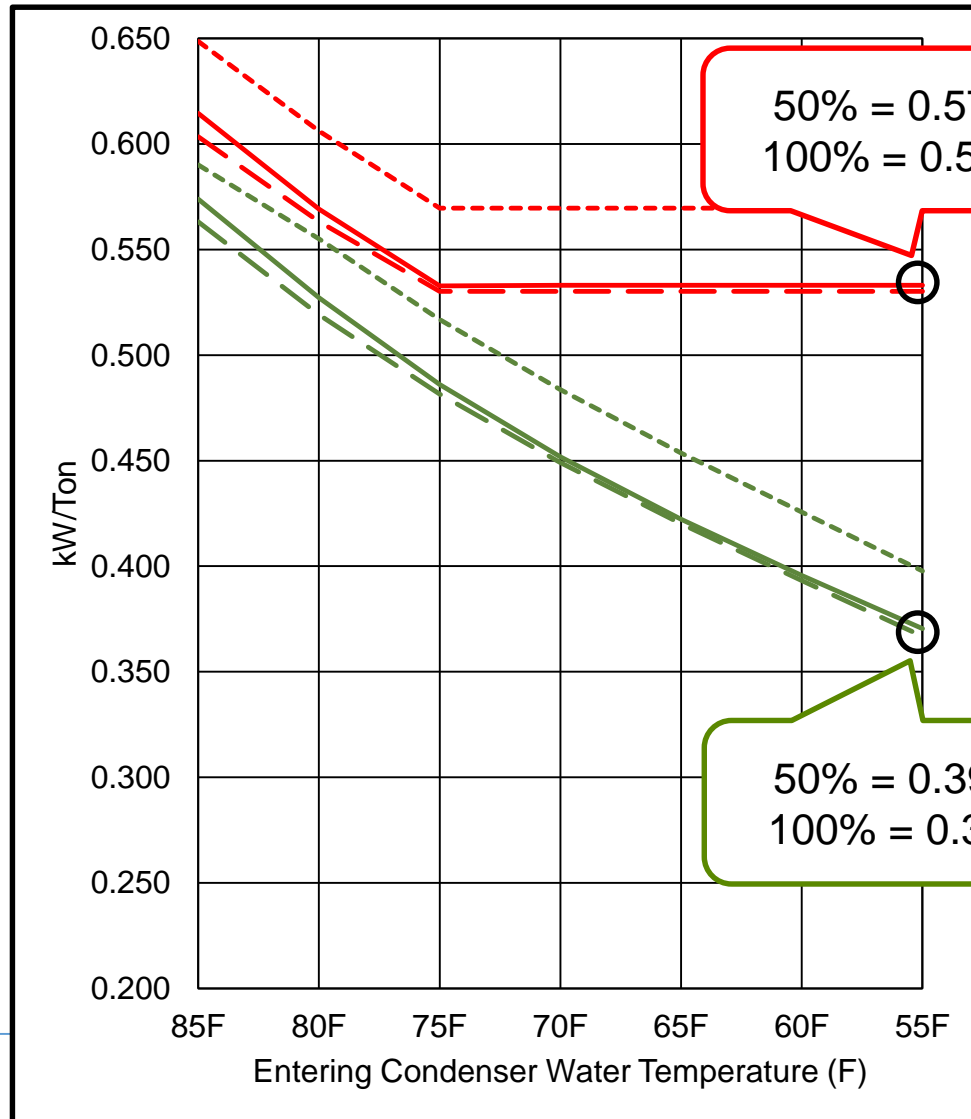
Real World Energy Performance

Capitalizing on Part Load Conditions -ECWT vs kW/ton



Real World Energy Performance

Capitalizing on Part Load Conditions -ECWT vs kW/ton

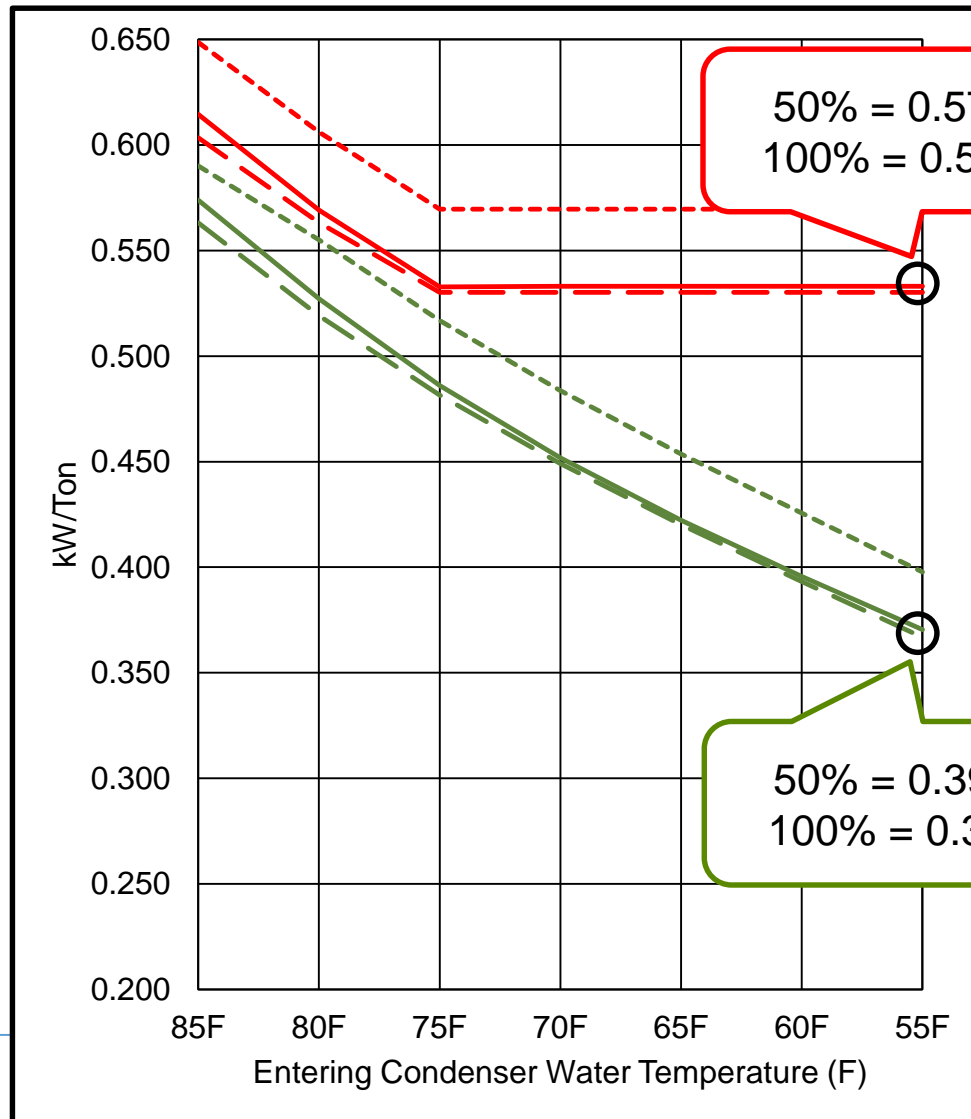


**Traditional – Constant Speed
w/ Fixed Orifice**

**New - Constant Speed
w/ Variable Orifice**

Real World Energy Performance

Capitalizing on Part Load Conditions -ECWT vs kW/ton



50% = 0.570 kW/ton
100% = 0.533 kW/ton

**Traditional – Constant Speed
w/ Fixed Orifice**

**New - Constant Speed
w/ Variable Orifice**

50% = 0.398 kW/ton
100% = 0.371 kW/ton

Assume 500ton chiller
50% load - difference of 43kW
100% load - difference of 81kW

Real World Energy Performance

Employing Variable Speed Technology to Maximize Efficiency

- Taking advantage of real world conditions
 - As weather conditions and building load change, design conditions exist only 1% of the operating hours
- Applying VSD to chillers reduces energy consumption by 30%
- Globally commissioned over 50,000 VSD
- **EPA's Prestigious Climate Protection Award**
 - YORK VSD chillers save 600,000 tons of CO₂ emissions annually



Real World Energy Performance

Fixed Speed vs Variable Speed

Comparison at AHRI conditions

<u>% Load</u>	<u>ECWT</u>
100	85.0
90	81.0
80	77.0
70	73.0
60	69.0
50	65.0
40	65.0
30	65.0
20	65.0
15	65.0

Real World Energy Performance

Fixed Speed vs Variable Speed

Comparison at AHRI conditions

<u>% Load</u>	<u>ECWT</u>
100	85.0
90	81.0
80	77.0
70	73.0
60	69.0
50	65.0
40	65.0
30	65.0
20	65.0
15	65.0

AHRI standards limit the
tower water to 65F
Entering Condenser
Water Temperature
(ECWT)

Real World Energy Performance

Fixed Speed vs Variable Speed

Comparison at AHRI conditions

<u>% Load</u>	<u>ECWT</u>	No VSD	VSD
		<u>KW/TON</u>	<u>KW/TON</u>
100	85.0	0.5737	0.5823
90	81.0	0.5284	0.5147
80	77.0	0.4958	0.4512
70	73.0	0.4730	0.3900
60	69.0	0.4589	0.3367
50	65.0	0.4536	0.2876
40	65.0	0.4870	0.2914
30	65.0	0.5429	0.3284
20	65.0	0.6575	0.3777
15	65.0	0.7639	0.4357

Real World Energy Performance

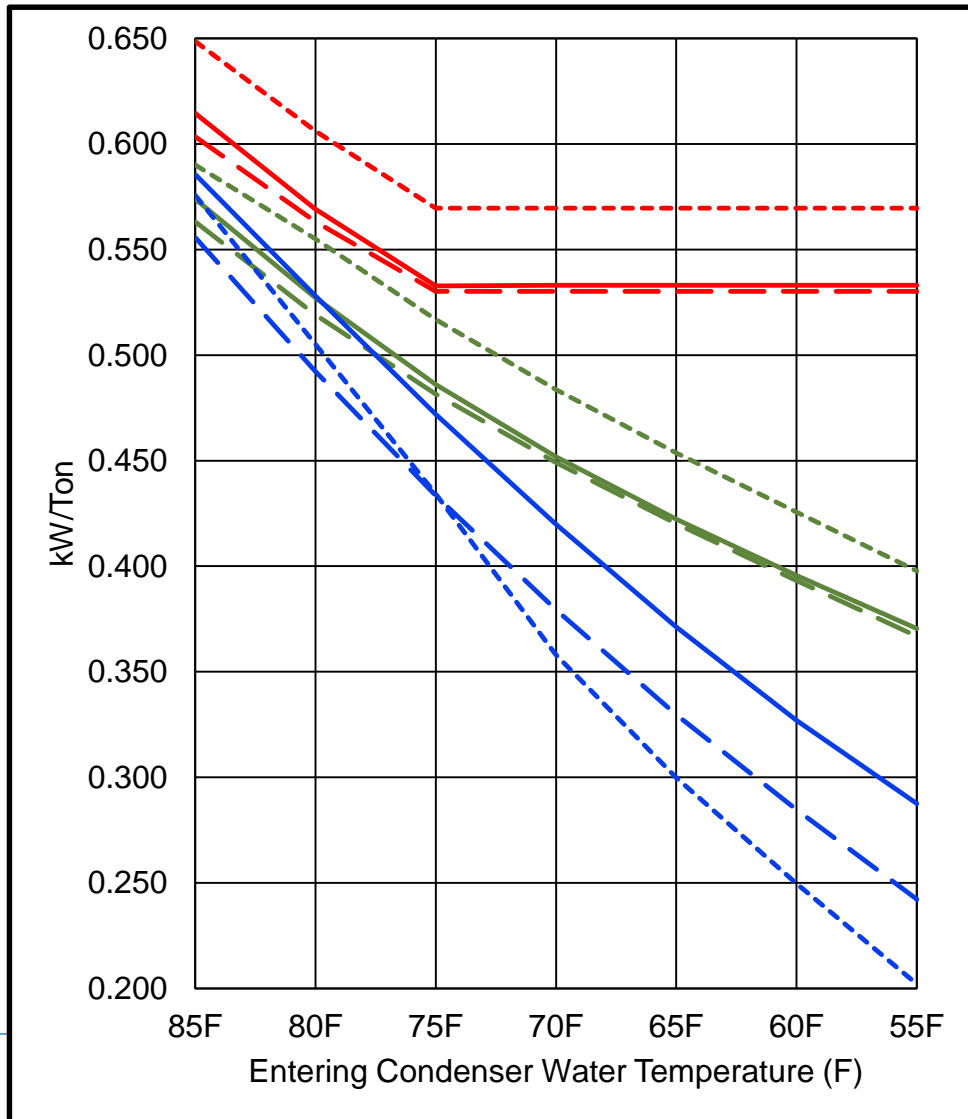
Fixed Speed vs Variable Speed

Comparison at AHRI conditions

<u>% Load</u>	<u>ECWT</u>	No VSD	VSD	<u>%SAVED</u>
		<u>KW/TON</u>	<u>KW/TON</u>	
100	85.0	0.5737	0.5823	-1.49
90	81.0	0.5284	0.5147	2.59
80	77.0	0.4958	0.4512	9.00
70	73.0	0.4730	0.3900	17.55
60	69.0	0.4589	0.3367	26.63
50	65.0	0.4536	0.2876	36.60
40	65.0	0.4870	0.2914	40.16
30	65.0	0.5429	0.3284	39.51
20	65.0	0.6575	0.3777	42.56
15	65.0	0.7639	0.4357	42.96

Real World Energy Performance

Fixed Speed vs Variable Speed



**Traditional – Constant Speed
w/ Fixed Orifice**

50% Load -----
100% Load _____
80% Load - . - . - .

**New - Constant Speed
w/ Variable Orifice**

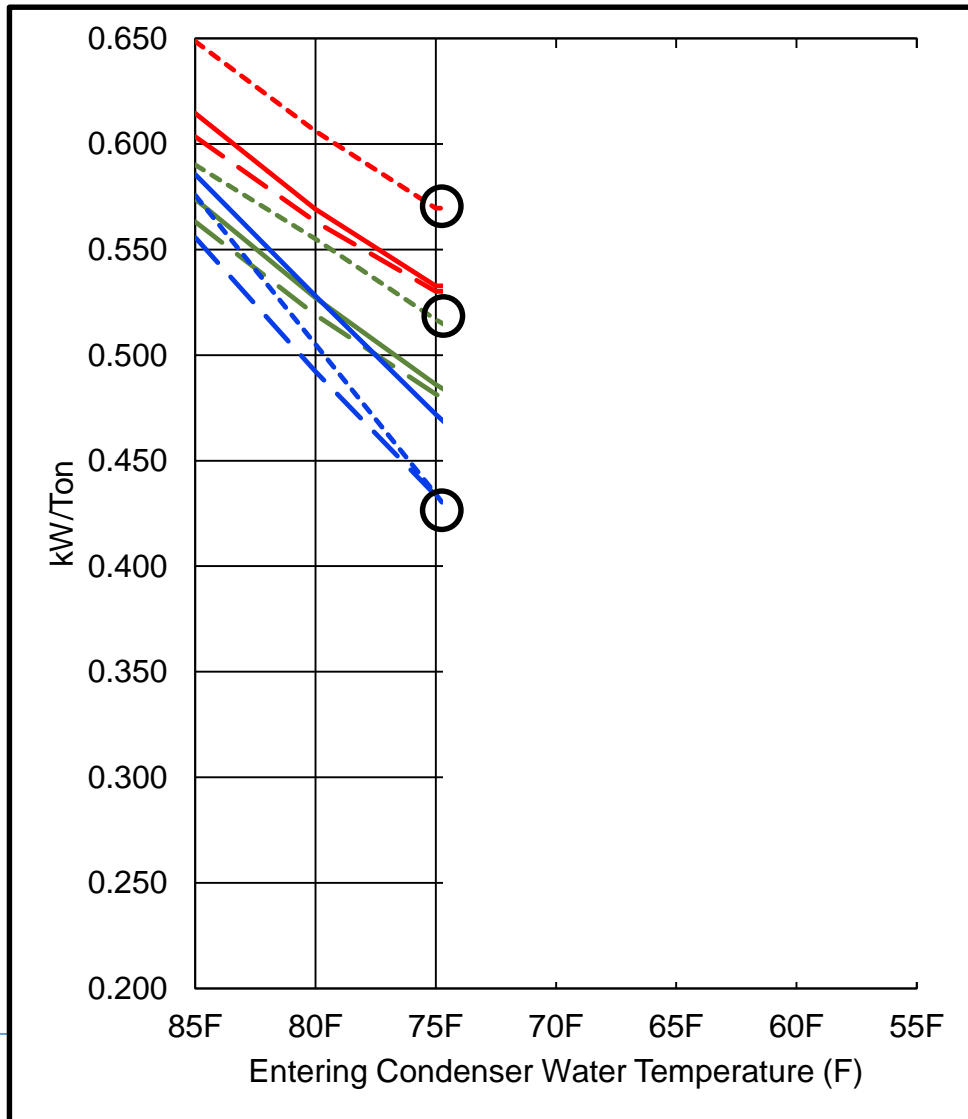
50% Load -----
100% Load _____
80% Load - . - . - .

**Variable Speed
w/ Variable Orifice**

100% Load _____
80% Load - . - . - .
50% Load -----

Real World Energy Performance

Fixed Speed vs Variable Speed



Traditional – Constant Speed w/ Fixed Orifice

50% Load -----
 100% Load _____
 80% Load - . - . - .

New - Constant Speed w/ Variable Orifice

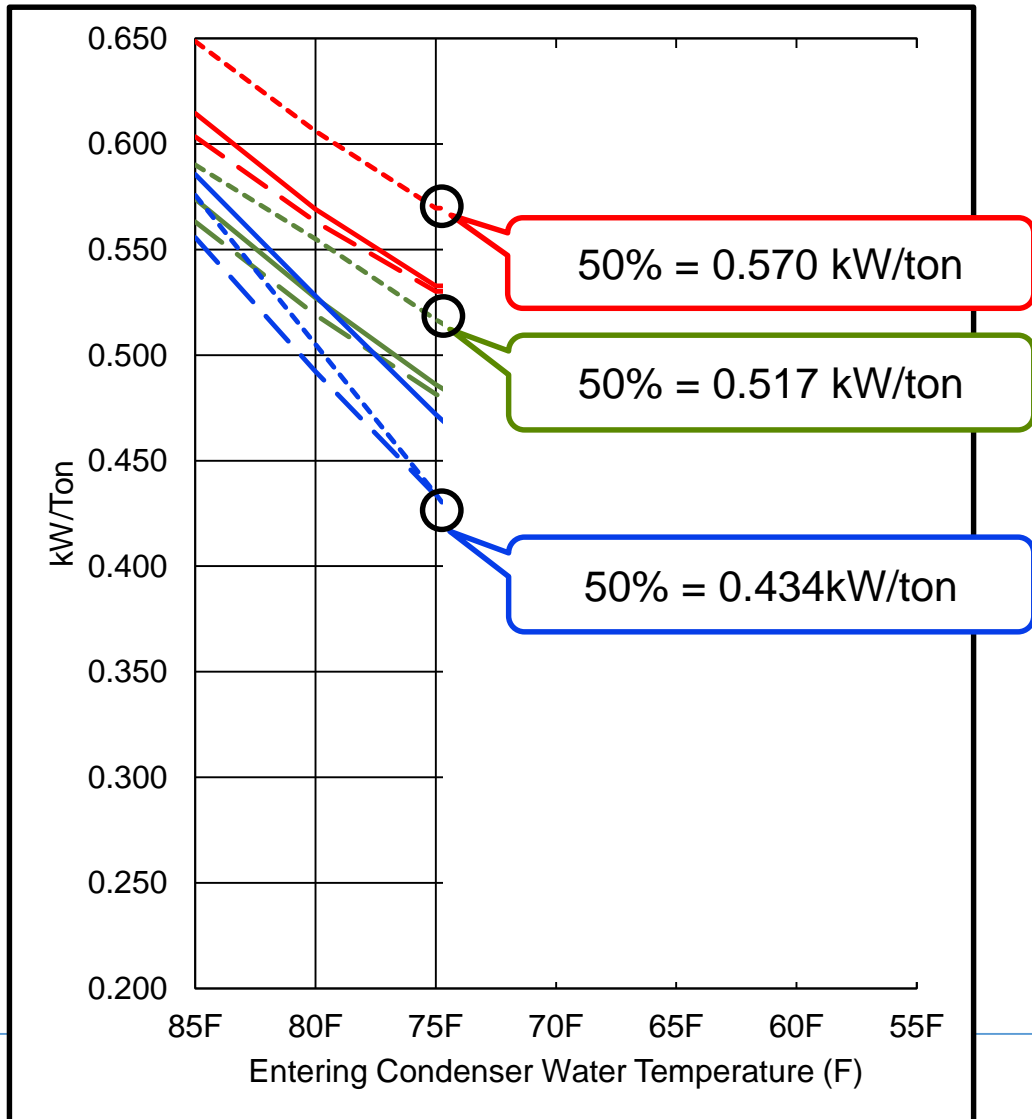
50% Load -----
 100% Load _____
 80% Load - . - . - .

Variable Speed w/ Variable Orifice

100% Load _____
 80% Load - . - . - .
 50% Load -----

Real World Energy Performance

Fixed Speed vs Variable Speed



Traditional – Constant Speed w/ Fixed Orifice

50% Load -----
 100% Load _____
 80% Load — — —

New - Constant Speed w/ Variable Orifice

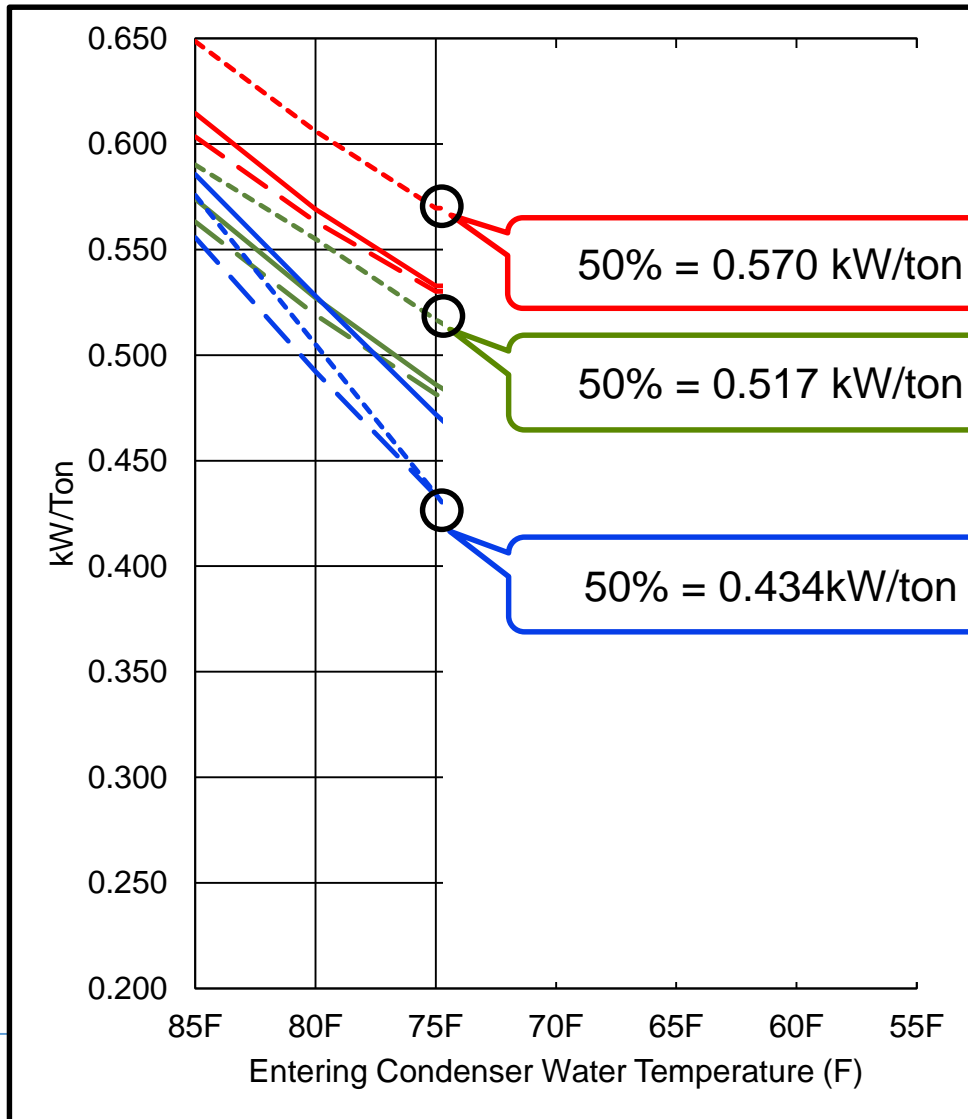
50% Load -----
 100% Load _____
 80% Load — — —

Variable Speed w/ Variable Orifice

100% Load _____
 80% Load — — —
 50% Load -----

Real World Energy Performance

Fixed Speed vs Variable Speed



**Traditional – Constant Speed
w/ Fixed Orifice**

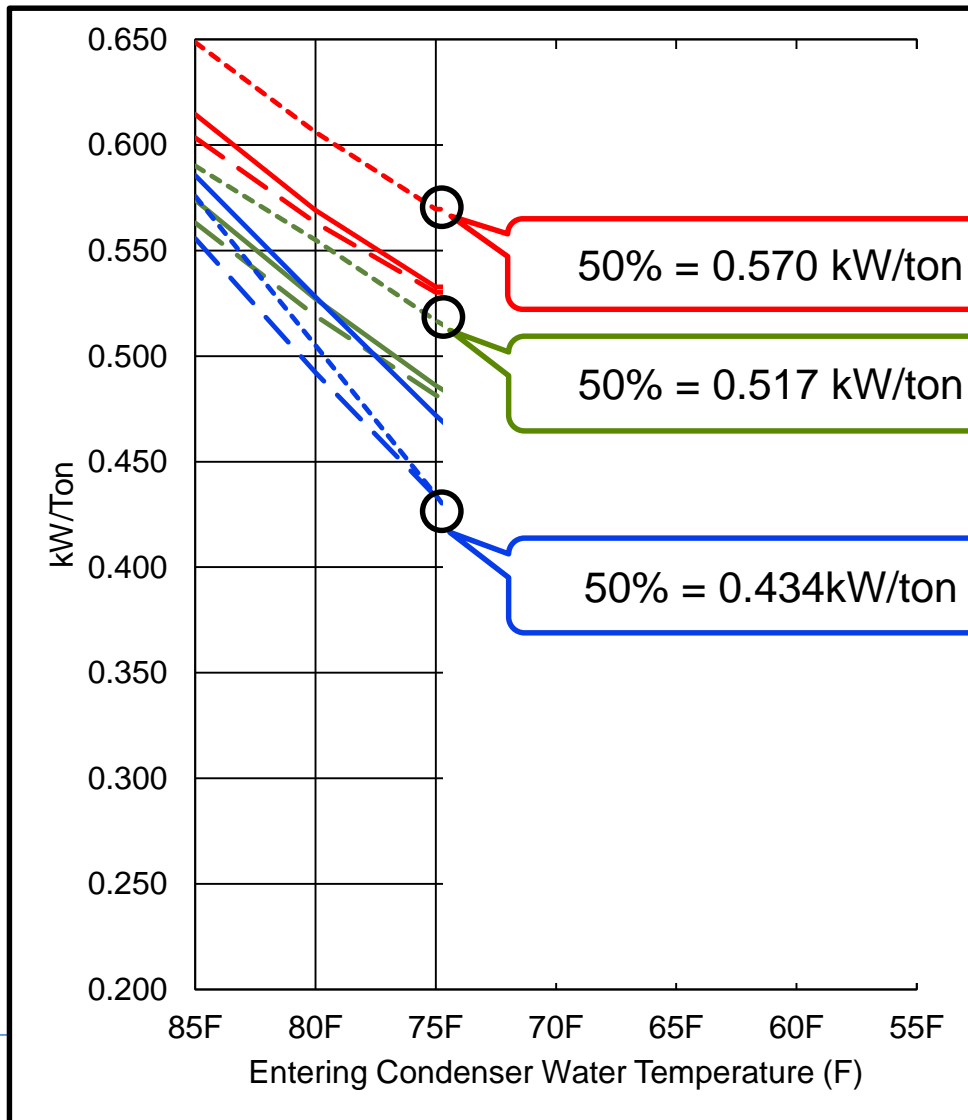
**New - Constant Speed
w/ Variable Orifice**

**Variable Speed
w/ Variable Orifice**

Assume 500ton chiller
50% load - difference of 20.75kW

Real World Energy Performance

Fixed Speed vs Variable Speed



**Traditional – Constant Speed
w/ Fixed Orifice**

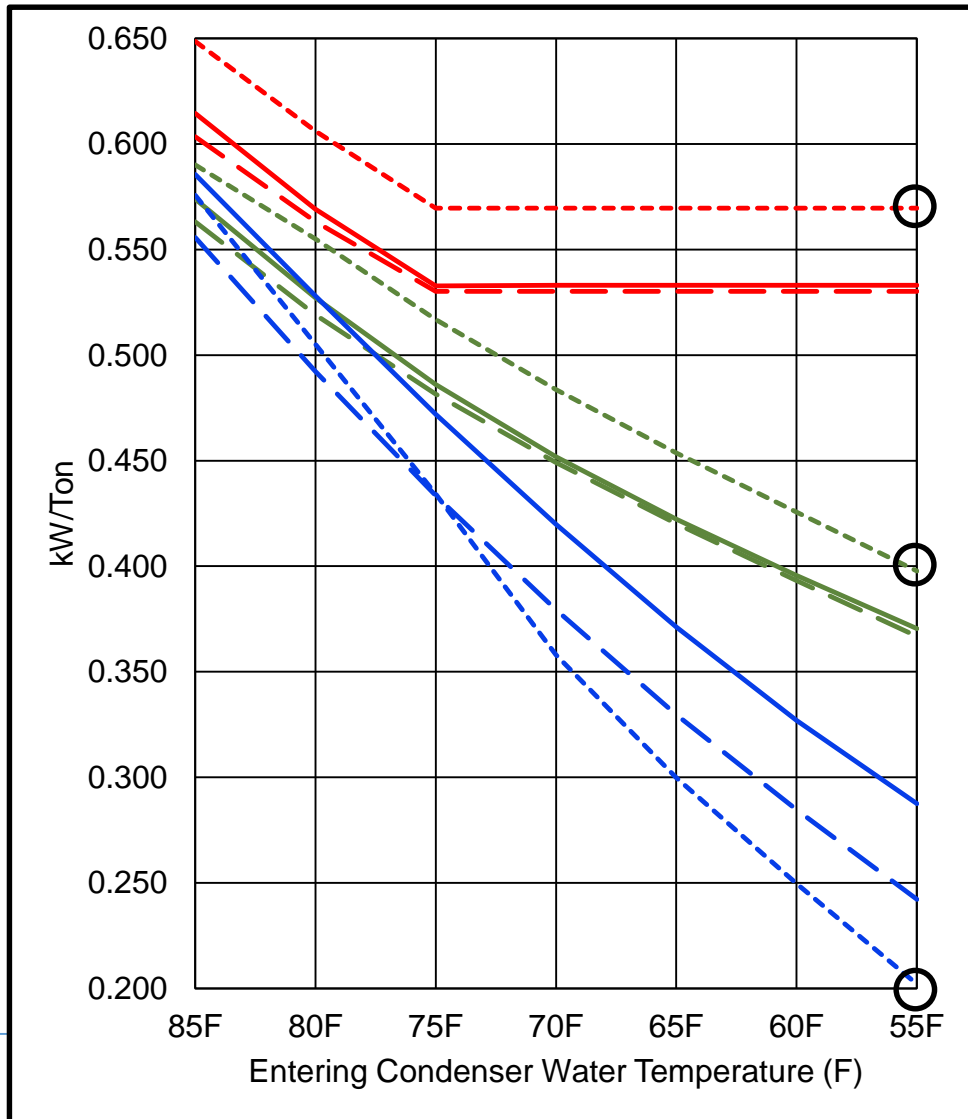
**New - Constant Speed
w/ Variable Orifice**

**Variable Speed
w/ Variable Orifice**

Assume 500ton chiller
50% load - difference of 34kW

Real World Energy Performance

Fixed Speed vs Variable Speed



Traditional – Constant Speed w/ Fixed Orifice

50% Load -----
 100% Load _____
 80% Load - - - - -

New - Constant Speed w/ Variable Orifice

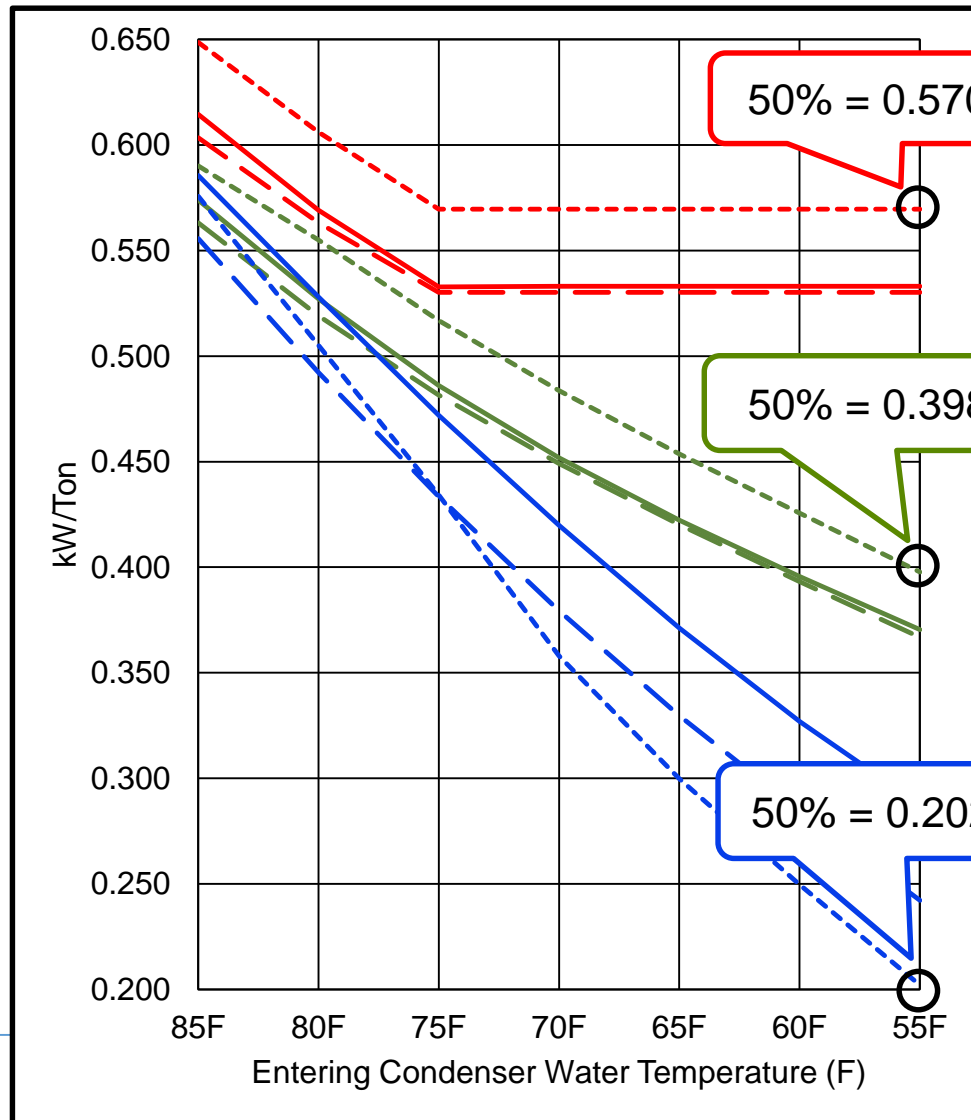
50% Load -----
 100% Load _____
 80% Load - - - - -

Variable Speed w/ Variable Orifice

100% Load _____
 80% Load - - - - -
 50% Load -----

Real World Energy Performance

Fixed Speed vs Variable Speed



**Traditional – Constant Speed
w/ Fixed Orifice**

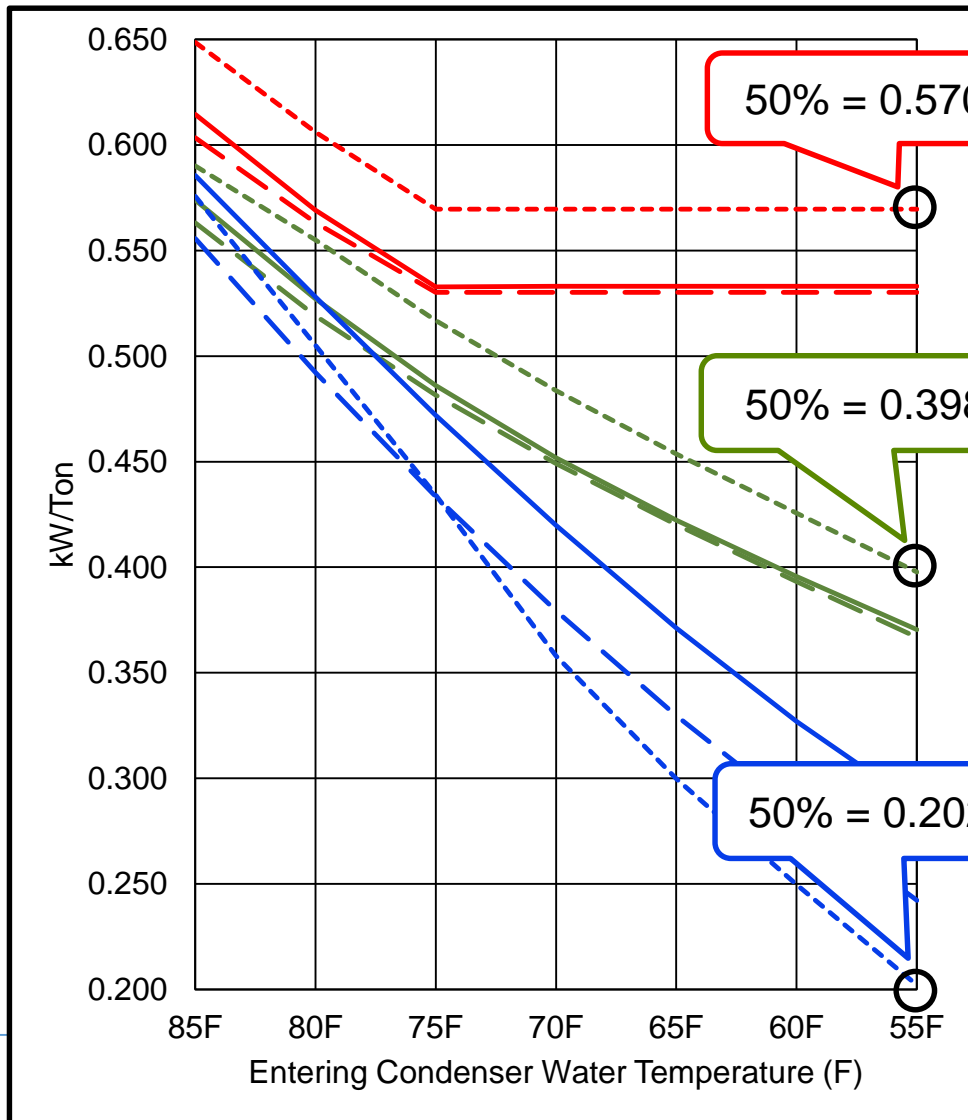
**New - Constant Speed
w/ Variable Orifice**

**Variable Speed
w/ Variable Orifice**

Assume 500ton chiller
50% load - difference of 49kW

Real World Energy Performance

Fixed Speed vs Variable Speed



**Traditional – Constant Speed
w/ Fixed Orifice**

**New - Constant Speed
w/ Variable Orifice**

**Variable Speed
w/ Variable Orifice**

Assume 500ton chiller
50% load - difference of 92kW

Innovations and Product Features

YORK *OptiSpeed*TM VSD

Unit mounted low voltage

- 460/575/600 V – 60 hz
- 380/400 – 50 hz

Floor mounted medium voltage

- 2300/3300/4000/4160 – 60 hz
- 3300 – 50 hz

Floor mounted **high** voltage

- 6.6kV/12.4kV/13.2kV/13.8kV – 60hz
- 6.6kV/10kV/11kV – 50hz

Benefits

- Full OptiView Communications
- YORK patented Adaptive Capacity Control
- Self learning for maximum efficiency



**Can a VSD save energy
on applications with
constant load year
round?**

Can a VSD save energy on applications with constant load year round?

- Data Center Applications
- Process Cooling Applications

VSD Use in a Constant Load Application

Assume a 500ton YMC² Chiller (Mag Bearing)

VSD chiller only!

Evap temperature: 54/44F

Cond temperature: 85/94.3F

Constant evap and cond flow

FL: 0.5261kW/ton

IPLV: 0.3058kW/ton

VSD Use in a Constant Load Application

Assume a 500ton YMC² Chiller (Mag Bearing)

VSD chiller only!

Evap temperature: 54/44F

Cond temperature: 85/94.3F

Constant evap and cond flow

FL: 0.5261kW/ton

IPLV: 0.3058kW/ton



Project:
Unit Tag:
Engineer:
Customer:

Rating Program: LTS 1.0.6337
Software Version: YW 17.02c
Date: 06/07/2017 14:37:10

Partload Data (Minimum Condenser Water Temperature)										
CEFT (°F)	% LOAD									
	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%
85.00°	0.5261	0.5119	0.4982	0.4915	0.4952	0.5084	0.5373	0.5953	0.7965	-
80.00°	0.4713	0.4532	0.4411	0.4335	0.4310	0.4377	0.4568	0.5061	0.6496	1.303
75.00°	0.4179	0.3995	0.3866	0.3783	0.3700	0.3757	0.3914	0.4214	0.5341	1.067
70.00°	0.3686	0.3499	0.3353	0.3240	0.3163	0.3138	0.3240	0.3488	0.4028	0.8141
65.00°	0.3258	0.3046	0.2880	0.2748	0.2652	0.2580	0.2613	0.2801	0.3188	0.6505
60.00°	0.2866	0.2639	0.2443	0.2287	0.2171	0.2087	0.2059	0.2175	0.2463	0.3741
55.00°	0.2510	0.2265	0.2049	0.1869	0.1730	0.1632	0.1571	0.1611	0.1798	0.2555
50.00°	0.2214	0.1936	0.1694	0.1502	0.1338	0.1198	0.1118	0.1082	0.1173	0.1592
45.00°	0.2043	0.1742	0.1468	0.1260	0.1030	0.08859	0.07884	0.08250	0.1263	0.2195
40.00°	0.1996	0.1729	0.1481	0.1255	0.09586	0.08172	0.07135	0.08988	0.1443	0.2233
39.00°	0.1995	0.1729	0.1483	0.1262	0.09614	0.08209	0.07116	0.08865	0.1429	0.2229
38.00°	0.1996	0.1732	0.1486	0.1267	0.09662	0.08318	0.07134	0.08744	0.1413	0.2225
37.00°	0.2000	0.1737	0.1490	0.1273	0.09841	0.08454	0.07247	0.08625	0.1397	0.2220
36.00°	0.2006	0.1744	0.1495	0.1279	0.1015	0.08593	0.07361	0.08508	0.1379	0.2215

**Values are in kW/Ton.R*

VSD Use in a Constant Load Application

Assume a 500ton YMC² Chiller (Mag Bearing)

VSD chiller only!

Evap temperature: 54/44F

Cond temperature: 85/94.3F

Constant evap and cond flow

FL: 0.5261kW/ton

IPLV: 0.3058kW/ton



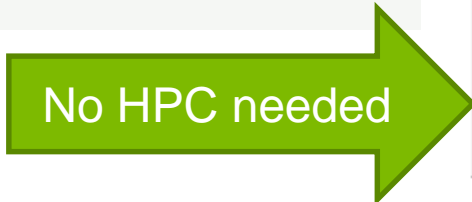
Project:
Unit Tag:
Engineer:
Customer:

Rating Program: LTS 1.0.6337
Software Version: YW 17.02c
Date: 06/07/2017 14:37:10

Partload Data (Minimum Condenser Water Temperature)

CEFT (°F)	% LOAD									
	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%
85.00°	0.5261	0.5119	0.4982	0.4915	0.4952	0.5084	0.5373	0.5953	0.7965	-
80.00°	0.4713	0.4532	0.4411	0.4335	0.4310	0.4377	0.4568	0.5061	0.6496	1.303
75.00°	0.4179	0.3995	0.3866	0.3783	0.3700	0.3757	0.3914	0.4214	0.5341	1.067
70.00°	0.3686	0.3499	0.3353	0.3240	0.3163	0.3138	0.3240	0.3488	0.4028	0.8141
65.00°	0.3258	0.3046	0.2880	0.2748	0.2652	0.2580	0.2613	0.2801	0.3188	0.6505
60.00°	0.2866	0.2639	0.2443	0.2287	0.2171	0.2087	0.2059	0.2175	0.2463	0.3741
55.00°	0.2510	0.2265	0.2049	0.1869	0.1730	0.1632	0.1571	0.1611	0.1798	0.2555
50.00°	0.2214	0.1936	0.1694	0.1502	0.1338	0.1198	0.1118	0.1082	0.1173	0.1592
45.00°	0.2043	0.1742	0.1468	0.1260	0.1030	0.08859	0.07884	0.08250	0.1263	0.2195
40.00°	0.1996	0.1729	0.1481	0.1255	0.09586	0.08172	0.07135	0.08988	0.1443	0.2233
39.00°	0.1995	0.1729	0.1483	0.1262	0.09614	0.08209	0.07116	0.08865	0.1429	0.2229
38.00°	0.1996	0.1732	0.1486	0.1267	0.09662	0.08318	0.07134	0.08744	0.1413	0.2225
37.00°	0.2000	0.1737	0.1490	0.1273	0.09841	0.08454	0.07247	0.08625	0.1397	0.2220
36.00°	0.2006	0.1744	0.1495	0.1279	0.1015	0.08593	0.07361	0.08508	0.1379	0.2215

*Values are in kW/Ton.R



VSD Use in a Constant Load Application

Assume a 500ton YMC² Chiller (Mag Bearing)

VSD chiller only!

Evap temperature: 54/44F

Cond temperature: 85/94.3F

Constant evap and cond flow

FL: 0.5261kW/ton

IPLV: 0.3058kW/ton



Project:
Unit Tag:
Engineer:
Customer:

Rating Program: LTS 1.0.6337
Software Version: YW 17.02c
Date: 06/07/2017 14:37:10

Partload Data (Minimum Condenser Water Temperature)

CEFT (°F)	% LOAD									
	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%
85.00°	0.5261	0.5119	0.4982	0.4915	0.4952	0.5084	0.5373	0.5953	0.7965	-
80.00°	0.4713	0.4532	0.4411	0.4335	0.4310	0.4377	0.4568	0.5061	0.6496	1.303
75.00°	0.4179	0.3995	0.3866	0.3783	0.3700	0.3757	0.3914	0.4214	0.5341	1.067
70.00°	0.3686	0.3499	0.3353	0.3240	0.3163	0.3138	0.3240	0.3488	0.4028	0.8141
65.00°	0.3258	0.3046	0.2880	0.2748	0.2652	0.2580	0.2613	0.2801	0.3188	0.6505
60.00°	0.2866	0.2639	0.2443	0.2287	0.2171	0.2087	0.2059	0.2175	0.2463	0.3741
55.00°	0.2510	0.2265	0.2049	0.1869	0.1711	0.1632	0.1571	0.1611	0.1798	0.2555
50.00°	0.2214	0.1936	0.1694	0.1502	0.1330	0.1198	0.1118	0.1082	0.1173	0.1592
45.00°	0.2043	0.1742	0.1468	0.1260	0.1030	0.0884	0.07884	0.08250	0.1263	0.2195
40.00°	0.1996	0.1729	0.1481	0.1255	0.09586	0.07135	0.07135	0.08988	0.1443	0.2233
39.00°	0.1995	0.1729	0.1483	0.1262	0.09614	0.08209	0.07116	0.08865	0.1429	0.2229
38.00°	0.1996	0.1732	0.1486	0.1267	0.09662	0.08318	0.07134	0.08744	0.1413	0.2225
37.00°	0.2000	0.1737	0.1490	0.1273	0.09841	0.08454	0.07247	0.08625	0.1397	0.2220
36.00°	0.2006	0.1744	0.1495	0.1279	0.1015	0.08593	0.07361	0.08508	0.1379	0.2215

No HPC needed

*Values are in kW/Ton.R

VSD Use in a Constant Load Application (100% load)

Assume a 500ton YMC² Chiller (Mag Bearing)

VSD chiller only!

Evap temperature: 54/44F

Cond temperature: 85/94.3F

Constant evap and cond flow

FL: 0.5261kW/ton

IPLV: 0.3058kW/ton

Process requires constant 500 tons



Project:
Unit Tag:
Engineer:
Customer:

Rating Program: LTS 1.0.6337
Software Version: YW 17.02c
Date: 06/07/2017 14:37:10

Partload Data (Minimum Condenser Water Temperature)										
CEFT (°F)	% LOAD									
	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%
85.00°	0.5261	0.5119	0.4982	0.4915	0.4952	0.5084	0.5373	0.5953	0.7965	-
80.00°	0.4713	0.4532	0.4411	0.4335	0.4310	0.4377	0.4568	0.5061	0.6496	1.303
75.00°	0.4179	0.3995	0.3866	0.3783	0.3700	0.3757	0.3914	0.4214	0.5341	1.067
70.00°	0.3686	0.3499	0.3353	0.3240	0.3163	0.3138	0.3240	0.3488	0.4028	0.8141
65.00°	0.3258	0.3046	0.2880	0.2748	0.2652	0.2580	0.2613	0.2801	0.3188	0.6505
60.00°	0.2866	0.2639	0.2443	0.2287	0.2171	0.2087	0.2059	0.2175	0.2463	0.3741
55.00°	0.2510	0.2265	0.2049	0.1869	0.1730	0.1632	0.1571	0.1611	0.1798	0.2555
50.00°	0.2214	0.1936	0.1694	0.1502	0.1338	0.1198	0.1118	0.1082	0.1173	0.1592
45.00°	0.2043	0.1742	0.1468	0.1260	0.1030	0.08859	0.07884	0.08250	0.1263	0.2195
40.00°	0.1996	0.1729	0.1481	0.1255	0.09586	0.08172	0.07135	0.08988	0.1443	0.2233
39.00°	0.1995	0.1729	0.1483	0.1262	0.09614	0.08209	0.07116	0.08865	0.1429	0.2229
38.00°	0.1996	0.1732	0.1486	0.1267	0.09662	0.08318	0.07134	0.08744	0.1413	0.2225
37.00°	0.2000	0.1737	0.1490	0.1273	0.09841	0.08454	0.07247	0.08625	0.1397	0.2220
36.00°	0.2006	0.1744	0.1495	0.1279	0.1015	0.08593	0.07361	0.08508	0.1379	0.2215

**Values are in kW/Ton.R*

VSD Use in a Constant Load Application (100% load)

Assume a 500ton YMC² Chiller (Mag Bearing)

VSD chiller only!

Evap temperature: 54/44F

Cond temperature: 85/94.3F

Constant evap and cond flow

FL: 0.5261kW/ton

IPLV: 0.3058kW/ton

Process requires constant 500 tons



Project:
Unit Tag:
Engineer:
Customer:

Rating Program: LTS 1.0.6337
Software Version: YW 17.02c
Date: 06/07/2017 14:37:10

Partload Data (Minimum Condenser Water Temperature)										
CEFT (°F)	% LOAD									
	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%
85.00°	0.5261									
80.00°	0.4713									
75.00°	0.4179									
70.00°	0.3686									
65.00°	0.3258									
60.00°	0.2866									
55.00°	0.2510									
50.00°	0.2214									
45.00°	0.2043									
40.00°	0.1996									
39.00°	0.1995									
38.00°	0.1996									
37.00°	0.2000									
36.00°	0.2006									

**Values are in kW/Ton.R*

VSD Use in a Constant Load Application (100% load)

Assume a 500ton YMC² Chiller (Mag Bearing)

VSD chiller only!

Evap temperature: 54/44F

Cond temperature: 85/94.3F

Constant evap and cond flow

FL: 0.5261kW/ton

IPLV: 0.3058kW/ton

Process requires constant 500 tons



Project:
Unit Tag:
Engineer:
Customer:

Rating Program: LTS 1.0.6337
Software Version: YW 17.02c
Date: 06/07/2017 14:37:10

Partload Data (Minimum Condenser Water Temperature)										
CEFT (°F)	% LOAD									
	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%
85.00°	0.5261									
80.00°	0.4713									
75.00°	0.4179									
70.00°	0.3686									
65.00°	0.3258									
60.00°	0.2866									
55.00°	0.2510									
50.00°	0.2214									
45.00°	0.2043									
40.00°	0.1996									
39.00°	0.1995									
38.00°	0.1996									
37.00°	0.2000									
36.00°	0.2006									

**Values are in kW/Ton.R*

Consuming 263.05kW

Consuming 125.5kW

VSD Use in a Constant Load Application (100% load)

Assume a 500ton YMC² Chiller (Mag Bearing)

VSD chiller only!

Evap temperature: 54/44F

Cond temperature: 85/94.3F

Constant evap and cond flow

FL: 0.5261kW/ton

IPLV: 0.3058kW/ton

Process requires constant 500 tons



Project:
Unit Tag:
Engineer:
Customer:

Rating Program: LTS 1.0.6337
Software Version: YW 17.02c
Date: 06/07/2017 14:37:10

Partload Data (Minimum Condenser Water Temperature)										
CEFT (°F)	% LOAD									
	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%
85.00°	0.5261									
80.00°	0.4713									
75.00°	0.4179									
70.00°	0.3686									
65.00°	0.3258									
60.00°	0.2866									
55.00°	0.2510									
50.00°	0.2214									
45.00°	0.2043									
40.00°	0.1996									
39.00°	0.1995									
38.00°	0.1996									
37.00°	0.2000									
36.00°	0.2006									

*Values are in kW/Ton.R

Consuming 263.05kW

Reduction of 52%

Consuming 125.5kW

VSD Use in a Constant Load Application (100% load)

Assume a 500ton YMC² Chiller (Mag Bearing)

VSD chiller only!

Evap temperature: 54/44F

Cond temperature: 85/94.3F

Constant evap and cond flow

FL: 0.5261kW/ton

IPLV: 0.3058kW/ton

Process requires constant 500 tons



Project:
Unit Tag:
Engineer:
Customer:

Rating Program: LTS 1.0.6337
Software Version: YW 17.02c
Date: 06/07/2017 14:37:10

Partload Data (Minimum Condenser Water Temperature)										
CEFT (°F)	% LOAD									
	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%
85.00°	0.5261									
80.00°	0.4713									
75.00°	0.4179									
70.00°	0.3686									
65.00°	0.3258									
60.00°	0.2866									
55.00°	0.2510									
50.00°	0.2214									
45.00°	0.2043									
40.00°	0.1996									
39.00°	0.1995									
38.00°	0.1996									
37.00°	0.2000									
36.00°	0.2006									

*Values are in kW/Ton.R

Consuming 263.05kW

Consuming 125.5kW

If I didn't have a VSD then my kW/ton would be a 0.371 @ 55F ECWT
I.e. consumption would be 185.5kW vs 125.5kW

VSD Use in a Constant Load Application (50% load)

Assume a 500ton YMC² Chiller (Mag Bearing)

VSD chiller only!

Evap temperature: 54/44F

Cond temperature: 85/94.3F

Constant evap and cond flow

FL: 0.5261kW/ton

IPLV: 0.3058kW/ton

Process requires constant 250 tons



Project:
Unit Tag:
Engineer:
Customer:

Rating Program: LTS 1.0.6337
Software Version: YW 17.02c
Date: 06/07/2017 14:37:10

Partload Data (Minimum Condenser Water Temperature)										
CEFT (°F)	% LOAD									
	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%
85.00°						0.5084				
80.00°						0.4377				
75.00°						0.3757				
70.00°						0.3138				
65.00°						0.2580				
60.00°						0.2087				
55.00°						0.1632				
50.00°						0.1198				
45.00°						0.08859				
40.00°						0.08172				
39.00°						0.08209				
38.00°						0.08318				
37.00°						0.08454				
36.00°						0.08593				

**Values are in kW/Ton.R*

VSD Use in a Constant Load Application (50% load)

Assume a 500ton YMC² Chiller (Mag Bearing)

VSD chiller only!

Evap temperature: 54/44F

Cond temperature: 85/94.3F

Constant evap and cond flow

FL: 0.5261kW/ton

IPLV: 0.3058kW/ton

Process requires constant 250 tons



Project:
Unit Tag:
Engineer:
Customer:

Rating Program: LTS 1.0.6337
Software Version: YW 17.02c
Date: 06/07/2017 14:37:10

Partload Data (Minimum Condenser Water Temperature)										
CEFT (°F)	% LOAD									
	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%
85.00°						0.5084				
80.00°						0.4377				
75.00°						0.3757				
70.00°						0.3138				
65.00°						0.2580				
60.00°						0.2087				
55.00°						0.1632				
50.00°						0.1198				
45.00°						0.08859				
40.00°						0.08172				
39.00°						0.08209				
38.00°						0.08318				
37.00°						0.08454				
36.00°						0.08593				

*Values are in kW/Ton.R

Consuming 127.1kW

Consuming 40.8kW

VSD Use in a Constant Load Application (50% load)

Assume a 500ton YMC² Chiller (Mag Bearing)

VSD chiller only!

Evap temperature: 54/44F

Cond temperature: 85/94.3F

Constant evap and cond flow

FL: 0.5261kW/ton

IPLV: 0.3058kW/ton

Process requires constant 250 tons



Project:
Unit Tag:
Engineer:
Customer:

Rating Program: LTS 1.0.6337
Software Version: YW 17.02c
Date: 06/07/2017 14:37:10

Partload Data (Minimum Condenser Water Temperature)										
CEFT (°F)	% LOAD									
	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%
85.00°						0.5084				
80.00°						0.4377				
75.00°						0.3757				
70.00°						0.3138				
65.00°						0.2580				
60.00°						0.2087				
55.00°						0.1632				
50.00°						0.1198				
45.00°						0.08859				
40.00°						0.08172				
39.00°						0.08209				
38.00°						0.08318				
37.00°						0.08454				
36.00°						0.08593				

*Values are in kW/Ton.R

Consuming 127.1kW

Reduction of 68%

Consuming 40.8kW

VSD Use in a Constant Load Application (50% load)

Assume a 500ton YMC² Chiller (Mag Bearing)

VSD chiller only!

Evap temperature: 54/44F

Cond temperature: 85/94.3F

Constant evap and cond flow

FL: 0.5261kW/ton

IPLV: 0.3058kW/ton

Process requires constant 250 tons



Project:
Unit Tag:
Engineer:
Customer:

Rating Program: LTS 1.0.6337
Software Version: YW 17.02c
Date: 06/07/2017 14:37:10

Partload Data (Minimum Condenser Water Temperature)										
CEFT (°F)	% LOAD									
	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%
85.00°						0.5084				
80.00°						0.4377				
75.00°						0.3757				
70.00°						0.3138				
65.00°						0.2580				
60.00°						0.2087				
55.00°						0.1632				
50.00°						0.1198				
45.00°						0.08859				
40.00°						0.08172				
39.00°						0.08209				
38.00°						0.08318				
37.00°						0.08454				
36.00°						0.08593				

*Values are in kW/Ton.R

Consuming 127.1kW

Consuming 40.8kW

If I didn't have a VSD then my kW/ton would be a 0.398 @ 55F ECWT

I.e. consumption would be 99.5kW vs 40.8kW

Running More Chillers in Part-load vs Full-load

Assume a 2x 500ton YMC² Chiller (Mag Bearing)

VSD chiller only!

Evap temperature: 54/44F

Cond temperature: 85/94.3F

Constant evap and cond flow

FL: 0.5261kW/ton

IPLV: 0.3058kW/ton

Do I run 1x
chiller at
100% load?

Do I run 2x
chiller at 50%
load?



Running More Chillers in Part-load vs Full-load

Assume a 2x 500ton YMC² Chiller (Mag Bearing)

VSD chiller only!

Evap temperature: 54/44F

Cond temperature: 85/94.3F

Constant evap and cond flow

FL: 0.5261kW/ton

IPLV: 0.3058kW/ton



Project:

Unit Tag:

Engineer:

Customer:

Rating Program: LTS 1.0.6337

Software Version: YW 17.02c

Date: 06/07/2017 14:37:10

Partload Data (Minimum Condenser Water Temperature)										
CEFT (°F)	% LOAD									
	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%
85.00°	0.5261	0.5119	0.4982	0.4915	0.4952	0.5084	0.5373	0.5953	0.7965	-
80.00°	0.4713	0.4532	0.4411	0.4335	0.4310	0.4377	0.4568	0.5061	0.6496	1.303
75.00°	0.4179	0.3995	0.3866	0.3783	0.3700	0.3757	0.3914	0.4214	0.5341	1.067
70.00°	0.3686	0.3499	0.3353	0.3240	0.3163	0.3138	0.3240	0.3488	0.4028	0.8141
65.00°	0.3258	0.3046	0.2880	0.2748	0.2652	0.2580	0.2613	0.2801	0.3188	0.6505
60.00°	0.2866	0.2639	0.2443	0.2287	0.2171	0.2087	0.2059	0.2175	0.2463	0.3741
55.00°	0.2510	0.2265	0.2049	0.1869	0.1730	0.1632	0.1571	0.1611	0.1798	0.2555
50.00°	0.2214	0.1936	0.1694	0.1502	0.1338	0.1198	0.1118	0.1082	0.1173	0.1592
45.00°	0.2043	0.1742	0.1468	0.1260	0.1030	0.08859	0.07884	0.08250	0.1263	0.2195
40.00°	0.1996	0.1729	0.1481	0.1255	0.09586	0.08172	0.07135	0.08988	0.1443	0.2233
39.00°	0.1995	0.1729	0.1483	0.1262	0.09614	0.08209	0.07116	0.08865	0.1429	0.2229
38.00°	0.1996	0.1732	0.1486	0.1267	0.09662	0.08318	0.07134	0.08744	0.1413	0.2225
37.00°	0.2000	0.1737	0.1490	0.1273	0.09841	0.08454	0.07247	0.08625	0.1397	0.2220
36.00°	0.2006	0.1744	0.1495	0.1279	0.1015	0.08593	0.07361	0.08508	0.1379	0.2215

*Values are in kW/Ton.R

Running More Chillers in Part-load vs Full-load

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VSD chiller only!

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Unit Tag:
Engineer:
Customer:

Rating Program: LTS 1.0.6337
Software Version: YW 17.02c
Date: 06/07/2017 14:37:10

Partload Data (Minimum Condenser Water Temperature)										
CEFT (°F)	% LOAD									
	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%
85.00°	Consumption of 208.95kW									
80.00°										
75.00°	0.4179	0.3995	0.3866	0.3783	0.3700	0.3757	0.3914	0.4214	0.5341	1.067
70.00°										
65.00°										
60.00°										
55.00°										
50.00°										
45.00°										
40.00°										
39.00°										
38.00°										
37.00°										
36.00°										

*Values are in kW/Ton.R

Consumption of 208.95kW

Each YMC² (2x) consumes
93.9kW
Total = 187.85kW
Reduction of ~10%

Running More Chillers in Part-load vs Full-load

Assume a 2x 500ton YMC² Chiller (Mag Bearing)

VSD chiller only!

Evap temperature: 54/44F

Cond temperature: 85/94.3F

Constant evap and cond flow

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IPLV: 0.3058kW/ton

Depending on your pumping strategy and cooling tower set up, you may have to turn on an additional pump or tower



Project:
Unit Tag:
Engineer:
Customer:

Rating Program: LTS 1.0.6337
Software Version: YW 17.02c
Date: 06/07/2017 14:37:10

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CEFT (°F)	% LOAD									
	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%
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55.00°	0.2510	0.2265	0.2049	0.1869	0.1730	0.1632	0.1571	0.1611	0.1798	0.2555
50.00°										
45.00°										
40.00°										
39.00°										
38.00°										
37.00°										
36.00°										

*Values are in kW/Ton.R

Consumption of 125.5kW

Each YMC² (2x) consumes 40.8kW
Total = 81.6kW
Reduction of ~35%

Running More Chillers in Part-load vs Full-load

What about additional run hours since I am running 2 chillers??

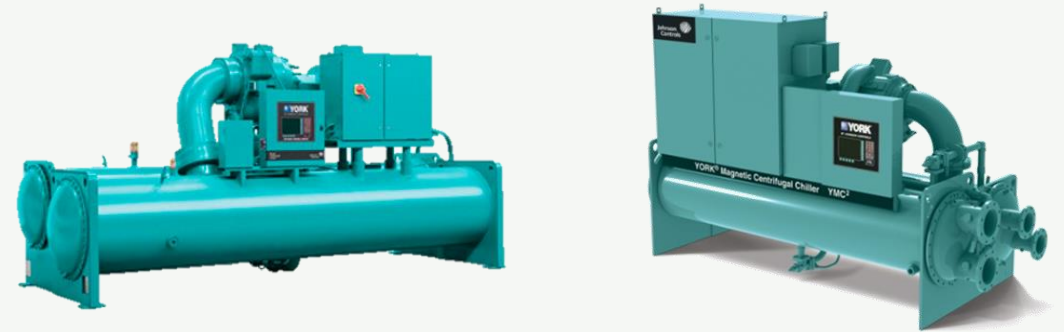


Running More Chillers in Part-load vs Full-load

What about additional run hours since I am running 2 chillers??



YORK centrifugal compressor designs **DO NOT** require a 40,000 hour compressor teardown



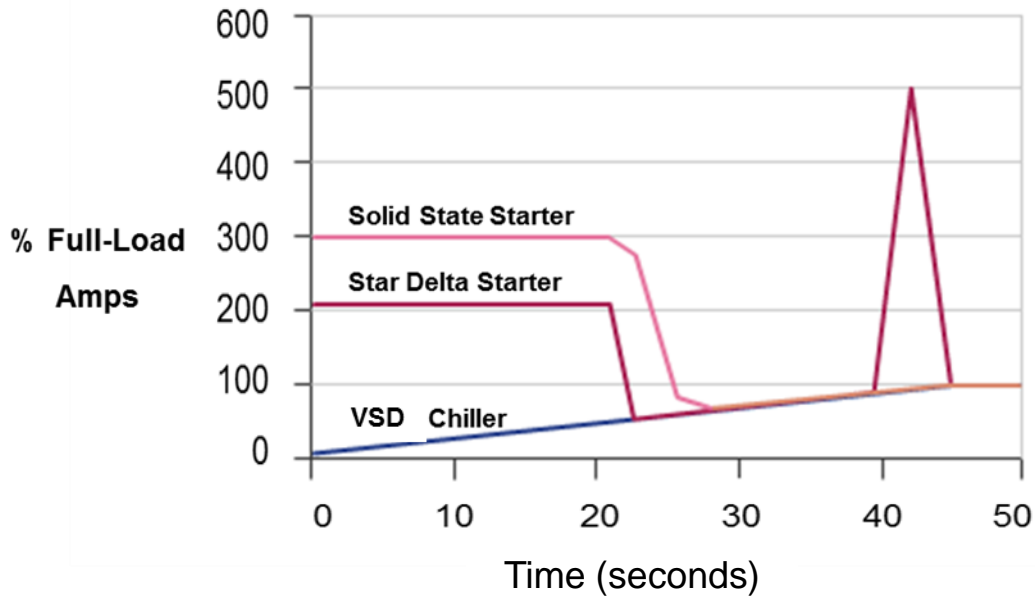
A typical chiller requires:

- Inspection of bearing wear, gears, etc. within the driveline
- Can cost approximately \$50,000+ per chiller every 10 years (4000 run hours a year)

Additional VSD Benefits

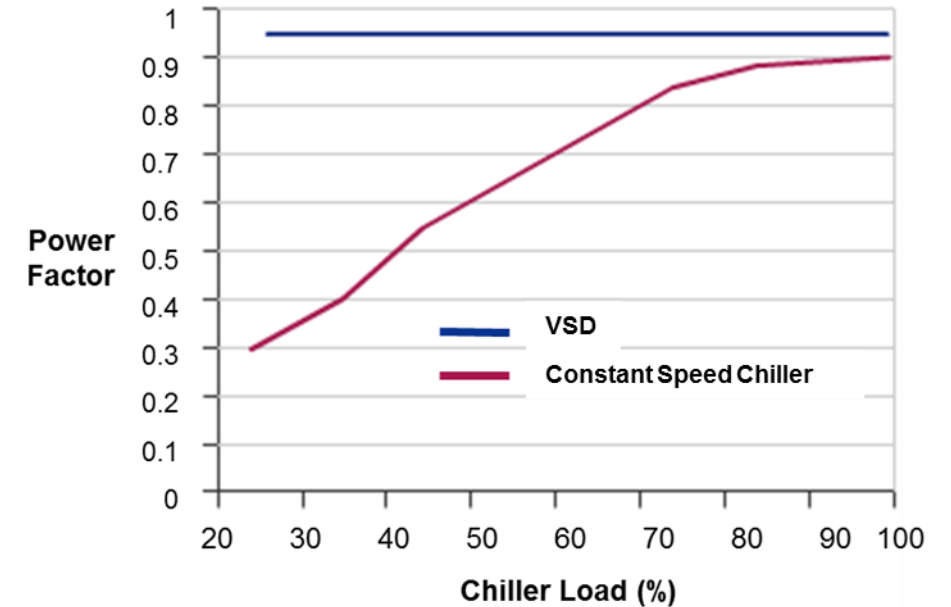
Zero Inrush

VSD reduces generator and no anti-recycle timer



High Power Factor

Eliminates the fear of power factor penalties by the utility company



Air-Cooled Screw Chillers

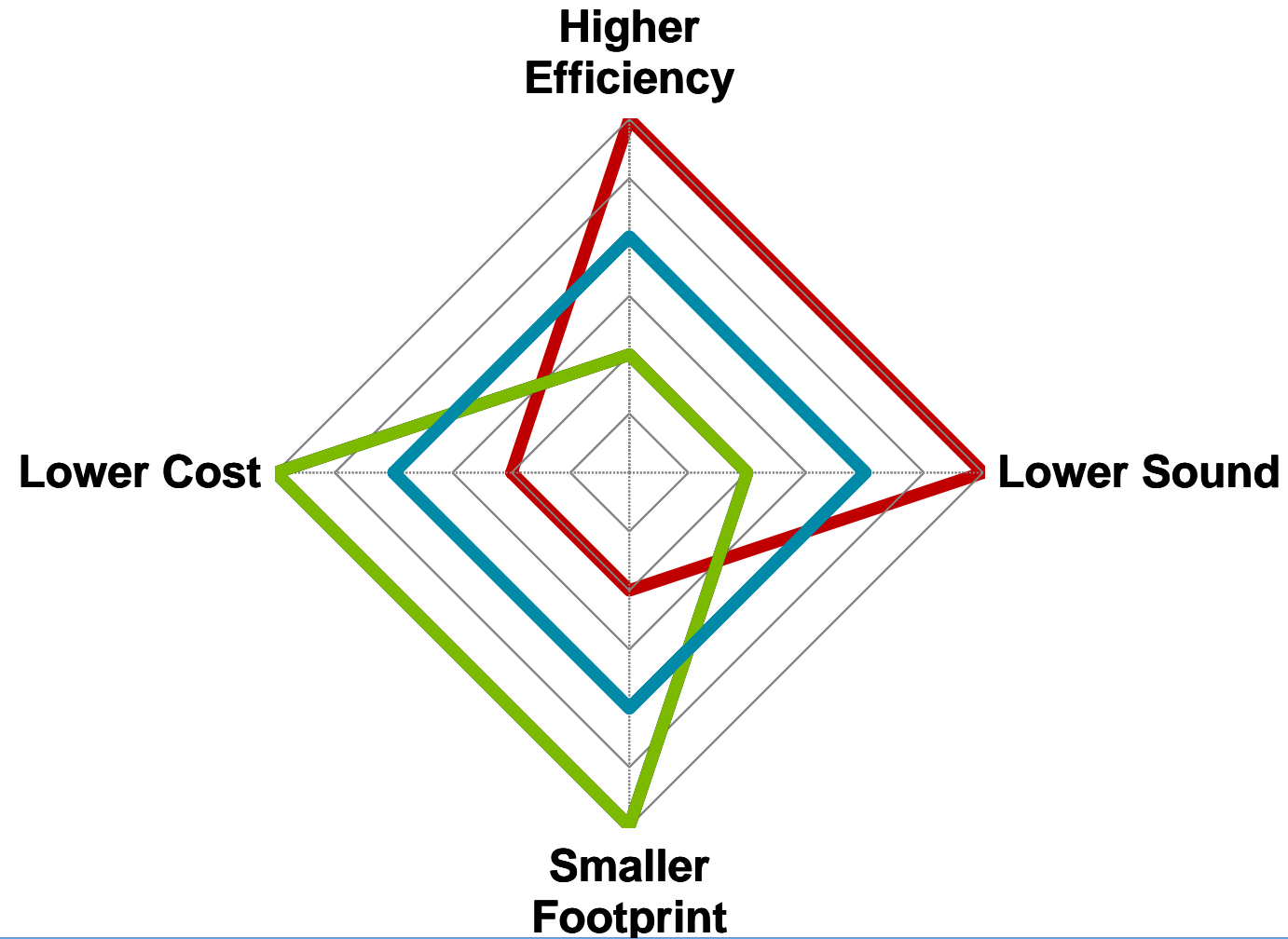
Redesign of Air-Cooled Screw Chillers in 2004

- Removal of “Slide Valves”
 - 50% less moving parts
 - 35% less leak paths
- Compressor speed varies due to the VSD
 - Compressors are now re-engineered



Air-Cooled Chillers

Tailor and Tune



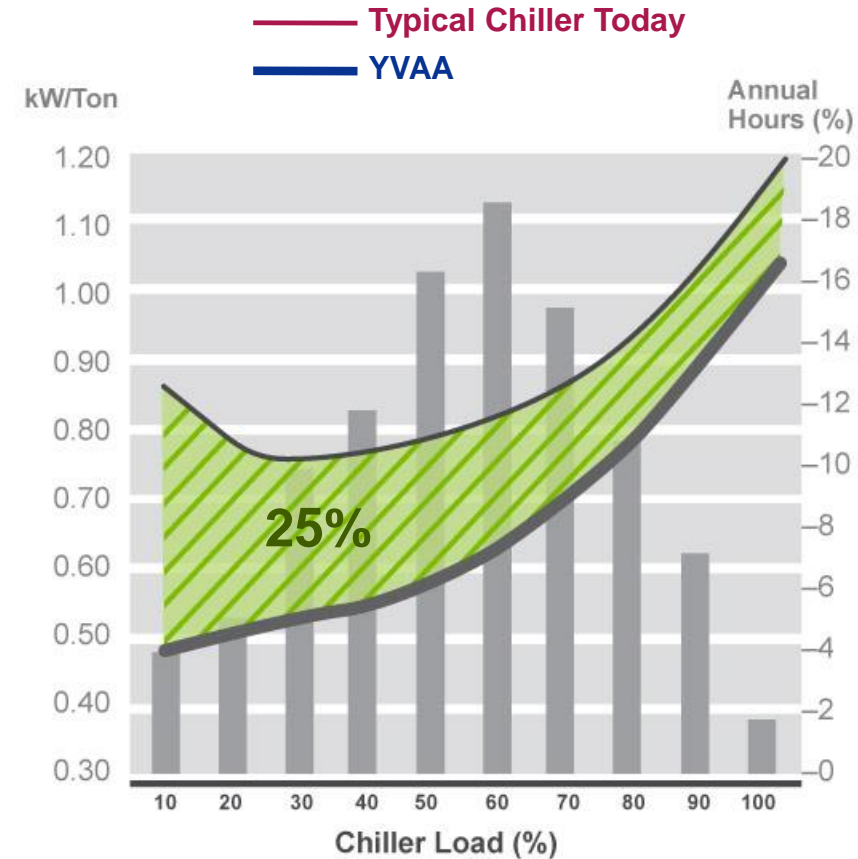
Air-Cooled Chillers

Tailor and Tune

VSD technology on Air-Cooled Screw Chillers

- Vastly improves the efficiency
- Greater energy savings in the year
- Flexible configurations
- Optimization for operating conditions

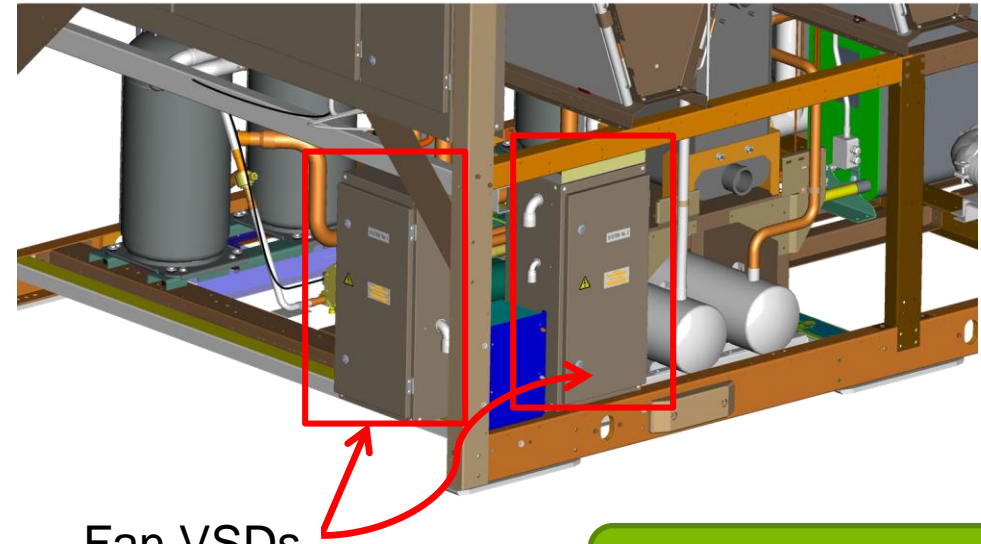
YVAA Efficiency vs. Ordinary Chiller



VSD on Condenser Fans

Placement of a VSD on each condenser fan circuit improves efficiency ~10%

YLAA Model*	AHRI Tons	Fixed Speed IPLV	VSD Fan IPLV	Payback (years)**
0058HE	57.0	15.6	16.8	1.8
0092HE	85.7	16.1	17.5	1.3
0142HE	129.5	15.9	17.1	1.1
0156HE	144.5	15.5	17.1	0.7
0175HE	172.5	15.6	17.1	0.7



Fan VSDs
(one per system)

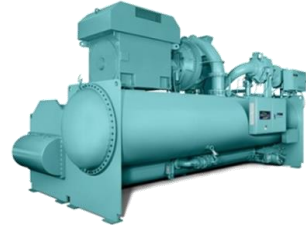
8 fan unit -> Each VSD controls 4x fans

*listing only a few models, VSD fans applicable for both screw and scroll chillers
**Payback may vary based on your building parameters

YORK Variable Speed Chiller Offering



Model YK
Single
Compressor



Model YKEP
Centrifugal
Extended Capacity



Model YD
Dual
Compressors



Model CYK
Compound Compressors



Model YMC²
Magnetic
Centrifugal



INSTALL CONFIDENCE



Model OM
Custom
Designed



Model YVWA
VSD Screw Unit



Model YVAA
VSD Air-Cooled Screw Chiller



Model YVFA
VSD Air-Cooled Screw Chiller
w/ Integrated Free Cooling

What else utilizes VSD's in today's HVAC industry?



Air Handlers



Cooling Towers



Pumps



VRF Systems

Conclusion

- **Real World Efficiency**
- **Lift provided enormous energy savings on chillers**
- **More chillers operating is more efficient**
- **Constant load with VSD saves money**



When to Install VSD Chillers

Q&A

Please submit any questions through the Question Window on your GoToWebinar interface, directing them to Chiller & Cooling Best Practices Magazine. Our panelists will do their best to address your questions, and will follow up with you on anything that goes unanswered during this session.

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Compression Engineering Corporation
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